ILLINOIS STATE GEOLOGICAL SURVEY ANNUAL REPORT

July 1989-June 1990

Illinois Department of Energy and Natural Resources

STATE GEOLOGICAL SURVEY DIVISION

ANNUAL REPORT

to the

BOARD OF NATURAL RESOURCES AND CONSERVATION

June 1989 to July 1990

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1989-90 HIGHLIGHTS AND SUMMARY

In the past fiscal year, the Illinois State Geological Survey continued to address major state issues, including those affecting

- Jobs and assurance of economic development and growth—employment and growth of Illinois' mineral extraction industries

- Energy—the adequacy of domestic liquid hydrocarbons for transportation and energy security

- Pollution prevention—protection of Illinois' groundwater supplies and reduction of atmospheric emissions

- Water—access to adequate supplies of clean groundwater

- Minerals—access to adequate supplies of construction materials to build or rebuild Illinois' infrastructure, and access to strategic and critical minerals reducing dependence on foreign sources.

- Land—its wise use

- Facilities and infrastructure—the need for information to site new facilities and rebuild existing infrastructure

- Agriculture—protection of prime farmlands

- Public safety and health—identification and minimization and geologic risks from natural and man-made hazards.

MINERAL RESOURCES AND ENGINEERING

Coal

- New 1:100,000-scale maps of coal-bearing counties in Illinois show the outlines of mined-out areas. Outlines of mined-out areas of active mines have been updated to January 1, 1989.

- Maps constructed for an area in southeastern Illinois indicate the presence of 2.7 billion tons of Davis Coal and 1.7 billion tons of Dekovan Coal resources. The amount available for development is now being determined.

- Because the finely divided coal resulting from some coal-cleaning processes is difficult to transport and market, ISGS researchers, working with scientists at the Tennessee Valley Authority and the University of Illinois, have developed a method of enlarging the particles to produce strong, durable pellets. The method uses lignocellusoic binders from lignic wastes. The pellets performed well in combustion testing.

- Supernatant liquids from cell preparations of specific bacteria have been shown to be useful for "wetting" the surfaces of pyrite grains so they will readily sink in froth flotation and other separation processes used to clean coal. The effects of the supernatant liquid on pyrite float-sink behavior are related to the concentration of proteins in the liquid. Current research is focusing on identifying this active agent.

- Studies sponsored by the Center for Research on Sulfur in Coal show that wet grinding high-chlorine Illinois coal to 80 percent -200 mesh size can reduce the chlorine content of the product by as much as

29 percent. Subsequent washing of the filter cake of the ground product with tap water at 93°C for 10 minutes can reduce the chlorine content by an additional 21 percent.

- The three-step CO-ethanol coal-desulfurization process is being tested in 1- and 4-pound-per-hour fluidized-bed reactors at the University of North Dakota Energy and Environmental Research Center. The recently patented 1-step ethanol coal-desulfurization process is also being tested, in 1- and 10-pound-per-hour fluidized-bed reactors at Ohio University. Preliminary results on the 1-step process indicate a 90 to 91 percent sulfur reduction on two Illinois coals and a 75 to 90 percent sulfur reduction on an Ohio coal.

- Depolymerizing Illinois Basin high-sulfur coal-lignin mixtures in a phenolic solvent in the presence of sodium carbonate and process gases (a mixture of H_2 and CO) in an autoclave at 345°C for 45 minutes resulted in a finely powdered, low-ash, low-sulfur product. This type of product may be useful as a fuel for turbines and diesel engines. Lignin, a waste product of the production of alcohol from vegetable matter, may help to compensate for volatile chemicals missing from the bituminous coals.

- Results of pilot-scale tests of an ISGS-developed, high-surface-area hydrated lime by the US EPA, Research Cottrell, and Consolidation Coal Company demonstrated a 25 to 85 percent increase in SO_2 removal over that achieved by a commercially prepared sulfur scavenger. The process for preparing this sorbent is proprietary, and an application for a patent has been prepared.

- Mild gasification experiments with an Illinois Basin coal showed that the addition of calcium oxide and the use of lower flow rates of steam improved the quality of the product oil.

Oil and Gas

- On June 28, 1989, the U.S. Department of Energy awarded $750,000 to the Illinois Department of Energy and Natural Resources for a program to improve the recovery of oil from existing fields in Illinois. This award represents the federal government's half of the first 12 months of a 4-year program to determine the best methods of recovering the estimated 1.5 billion barrels of by-passed, mobile oil remaining in Illinois reservoirs. Twelve reservoirs in southern Illinois producing from the Aux Vases and Cypress Sandstones—two of the most prolific oil-bearing units in the state—have been selected for study. Heterogeneities that control or limit fluid flow behavior in these reservoirs are now being identified; this essential step is critical to developing techniques to maximize the recovery of hydrocarbons.

- Source-rock studies suggest that shales of the Maquoketa Formation in combination with sandstone beds in southwestern Illinois offer a potential source/trap play. The sandstones may also have served as potential carrier beds for hydrocarbon migration.

Well Database System

- Development and installation of the CONQuEST data management systems for data entry, editing, and retrieval tasks have increased the ease and efficienty of database enhancement and management tasks. The QuARTZ and TOPAZ data retrieval systems, which are part of this system, were demonstrated at the recent meeting of the American Association of Petroleum Geologists in San Francisco. Industry indicated an interest in these data retrieval systems, and the market for the software is currently being investigated.

- To expand the Survey's well database system, data from 40,199 oil and gas wells in Illinois were acquired from Petroleum Information, Incorporated, validated, and transferred into the Survey's database. Data from some 13,000 holes drilled before 1915 also were entered in the system. In addition, more than 25,000 water-well permits and logs were entered into the Survey's computer database, using the CONQuEST data-entry program developed by the Well Data Base Unit. Files have been expanded to make these records available to the staff and the public.

Groundwater Resources

- A 5-year project to assess groundwater resources in the Quaternary Prairie Aquigroup is focusing on glacial deposits in parts of Bureau, Henry, Lee, Rock Island, and Whiteside Counties. The shallow Silurian bedrock in the same area of northwestern Illinois is also being investigated for its groundwater potential.

- A draft report was completed on the geologic framework, distribution, and hydrologic properties of the principal sand and gravel aquifers in the region of McLean County that includes Bloomington and Normal. A final report was completed for the City of Bloomington on the nature of the bedrock topography in the Danvers Bedrock Valley and on the character of alluvial deposits as determined from seismic refraction and resistivity surveys.

- In a project mandated by the Water Use Act of 1983, Survey staff members helped to evaluate the potential impacts of 218 existing or proposed large-capacity water wells (capable of supplying municipal or industrial needs) on groundwater in the surrounding region.

- Electrical resistivity surveys were conducted at another 65 sites to help municipalities, government agencies, farmers, and landowners locate water supplies or to detect changes in water salinity.

- Survey staff members responded to numerous queries from well drillers, farmers, citizens, industries, and government agencies desiring to locate, develop, use, or protect groundwater resources: they wrote 126 groundwater possibilities reports and 150 letters, handled 1,400 phone calls, and conferred in their offices with approximately 100 visitors seeking information.

- During FY90, 72 geophysical logs were run at 44 sites to provide interpretations of the chemical and physical characteristics of earth materials encountered in boreholes.

Industrial and Metallic Minerals

- Various types of products are being prepared to illustrate the distribution and potential of industrial and metallic minerals in southern Illinois, as part of a joint project—the Conterminous U.S. Mineral Assessment (CUSMAP)—with the USGS. Products include bedrock geology maps, surficial deposits and stack-unit maps, a compilation of mines and prospects, cross sections, isopach and lithofacies maps, maps of limestone, sand and gravel, clay, mineral, and coal resource maps, and subsurface geochemistry and thermal histories of the area.

- A manuscript based on data from 30 cores drilled for the Superconducting Super Collider (SSC) project and more than 100 cores drilled by the Metropolitan Water Reclamation District of Greater Chicago was completed. The report, focusing on the subsurface geology of the Greater Chicago area, provides data useful in planning underground mining of aggregate sources as surface reserves become limited.

- A detailed map of a 3-square-mile area west of Elco in Alexander County was prepared to show the distribution of tripoli deposits that occur in the Devonian Clear Creek Chert. Also completed was a 1-year study of the geology of these deposits, highlighting their hydrothermal-groundwater origin.

- A computerized mill has been constructed to examine the effectiveness of various processes used to grind or crush mineral products and to investigate ways of achieving energy savings in grinding and milling processes.

Mineral Economics

- An analysis of fossil-fuel prices in the 1971-1988 period shows that coal prices were not influenced by oil prices, but by events in the U.S. coal mining industry and in the world steel industry. The insulation of coal prices from the impacts of oil and gas prices, coupled with the restrictions on nuclear electricity generation, suggests that any increase in electricity consumption would benefit the coal industry more directly now than in the past.

- The total value of minerals extracted from the ground in Illinois was $2.5 billion in 1989. Sand and gravel production reached a record level of 100 million tons because of the continued growth in the construction activity.

- The Directory of Illinois Mineral Producers for 1988-89 was published.

ENVIRONMENTAL GEOLOGY AND GEOCHEMISTRY

Environmental Studies and Assessments

- Under a new environmental property-assessment project, ISGS scientists have received 148 requests and have completed 94 site assessment reports on possible man-made and natural hazards present on roadway that has been or will be acquired by the Illinois Department of Transportation.

- Using records from more than 1200 wells along with other map information, ISGS staff members prepared geological information for a Land Report in response to a Lands Unsuitable for Mining petition in Knox County.

- Maps for 105 surface and underground mine permit areas were added to the GIS database for the Lands Unsuitable for Mining Program (LUMP) during the past fiscal year.

Geology for Planning

- Phase I work to collect additional subsurface data by drilling continues in a geology-for-planning study for Kane County activated in February 1990. Work has begun on phase II goals, including the development of "slice" maps that depict the geology at various depths.

Lake Michigan Coast and Basin Studies

- The aerial photo file library of Lake Michigan's Shoreline now consists of about 65,000 photos taken from the 1930s through May 1990. The collection includes more than 600 color photos taken in May.

- During monitoring of littoral drift at the new North Point Marina in Illinois Beach State Park, ISGS coastal geologists noted exceedingly rapid shore erosion that threatened newly constructed facilities. This information led to the construction of a semipermanent block revetment to protect the threatened shore area and the adjacent parking lots.

- Using antique maps and surveys and modern computer graphic techniques, Survey researchers reconstructed shoreline positions along the entire Illinois shoreline of Lake Michigan from as early as 1834. Erosional and depositional histories can thus be deciphered through recent historical time.

- In a cooperative study, the USGS and the ISGS are mapping the extent of the remains of an ancient forest on the floor of Lake Michigan. Radiocarbon dating of samples of the stumps determined that the wood is more than 8,000 years old. The location of the tree stumps indicates that the ancestral Lake Michigan at that time was 90 feet or more lower than the present lake level.

Rivers, Backwater Lakes, and Wetlands Research

- Groundwater levels in experimental wetlands areas along the Des Plaines River have been monitored in 76 wells on a monthly basis since late 1987. A mathematical groundwater model used to estimate groundwater flux has indicated that the experimental wetlands areas are losing water to the subsurface, but the rate of loss is insignificant compared to the capacity of the pumps.

Hydrogeologic Investigations and Groundwater Protection

- A comprehensive literature review on the impacts of landfills on groundwater quality was conducted. On the basis of case studies and the potential efficacy of federal guidelines in Illinois, the public's concern for groundwater contamination by future municipal landfills may be unjustified.

- A pilot study initiated by the ISGS and ISWS in cooperation with the Illinois Department of Agriculture provides a preliminary assessment of the occurrence of agricultural chemicals in rural private wells in representative settings. Sampling and analytical procedures are being evaluated.

- In February the the Geological and Water Surveys sent members of the General Assembly copies of a groundwater report with an initial evaluation of the potential impacts of agricultural practices on groundwater quality. The report describes steps that can be taken to minimize the effects of agricultural practices on groundwater quality and indicates that shallow aquifers are vulnerable to contamination in places.

- To assist the Department of Mines and Minerals and the oil industry in locating the depth at which well casing must be set to protect potential drinking water supplies, the Survey is constructing a series of east-west and north-south cross sections illustrating the relationship between stratigraphy and total dissolved solids in groundwater in 19 counties. Cross sections have been completed in six of the counties.

- In a project to study the impact of leachates from composting yard wastes, ISGS scientists evaluated 98 chemicals commonly used by homeowners for yard and garden applications. They concluded that residue should be monitored at a controlled location, inasmuch as data from environmental site monitoring are lacking for most of the chemicals expected to be generated by composting yard wastes.

- A reduced-scale copy of the Potential for Aquifer Recharge in Illinois map was distributed to the General Assembly and key state agencies. The full-size map is now being printed.

- The ENR geographic information system (GIS) was used to automate location data for 546 underground petroleum-product storage tanks in Illinois IEPA Regions 1 and 2. A model of the vulnerability of shallow and deep aquifers to contamination was used to rank the relative contamination potential of the 546 tank locations. The model and location data are being used by Camp, Dresser and McKee to determine which sites the IEPA should investigate first for possible groundwater contamination problems from leaking underground storage tanks.

- Experiments with a field-scale clay liner show that the hydraulic conductivity (a measure of the rate of flow of water through earth materials) is about 4×10^{-8} cm/sec, significantly lower than the EPA maximum of 1×10^{-7} cm/sec.

Waste Management

- In cooperation with ENR's Office of Solid Waste and Renewable Resources and the Office of Research and Planning, the ISGS is currently providing assistance to Champaign and Lake Counties in screening areas for potential solid-waste disposal sites. GIS-generated maps shown at a final presentation to the Champaign County Intergovernmental Solid Waste Disposal Association depicted the distribution and thickness of major aquifers in the county. Areas generally suitable for further evaluation for landfill siting were noted. The new "slice" maps developed recently show the stratigraphy and lithology of Quaternary deposits in the county at selected intervals to a depth of 400 feet.

- An evaluation of underground injection practices in Illinois, mandated by the Illinois Environmental Protection Act, was published in August. The report concluded that where no other economical alternative exists, underground injection of some classes of industrial wastes is a safe disposal method. Testimony has been provided to the Illinois Pollution Control Board on the deep well-injection of industrial wastes as a part of the Underground Injection Control program.

- Minerals formed when injected industrial wastes react with rocks in the injection zones in Illinois have been studied in the laboratory. Comparisons between actual mineral products and the minerals predicted by computer models show that the computer models accurately predict some mineral products, but that additional data on thermodynamic properties of solutes in high ionic strength solutions are needed to improve the accuracy of the computer models.

- As part of oversight efforts related to the siting of a low-level nuclear waste facility near Martinsville, the ISGS reviewed chapters of Battelle's final report, *Stratigraphy, Hydrology, Geochemistry, Mineral Resources, and Groundwater Modelling* in Volumes 2 and 3 of the site characterization program study. During this reporting period, ISGS staff members testified before the Illinois Senate Executive Committee investigating the siting process for a low-level radioactive waste facility.

Earth Hazards and Geotechnical Studies

- *Seismicity in Illinois* (ISGS Environmental Geology 133), published during the report year, provides information on earthquakes in the state and includes a complete listing of earthquakes that have occurred in Illinois since 1795. The energy released by all the historical earthquakes epicentered in Illinois is less than the energy released by just one of the significant New Madrid earthquakes in 1811-1812. The authors conclude that the greatest seismic risk in Illinois is from earthquakes that may originate in the New Madrid Seismic Zone.

- Geological Survey geophysicists and engineering geologists made significant contributions to the deliberations and reports of the Seismic Risk Committee of the Governor's Earthquake Preparedness Task Force.

- Studies by scientists participating in the Illinois Mine Subsidence Research Program have shown that (1) fracturing of the Pennsylvanian sandstone units over subsided longwall panels actually increases the hydraulic conductivity and storativity of these generally poor-quality aquifers without significantly affecting water levels; (2) at two sites monitored for mine subsidence, water levels dropped when coal was mined under or near the wells; the water levels recovered within three months; and (3) soybean yields on subsided farm fields that have been mitigated are higher than yields for nearby nonsubsided fields. Corn yields on mitigated fields are about the same as on nonsubsided fields.

- In a study for the Illinois Mine Subsidence Insurance Fund (IMSIF), maps and tables were prepared for every county in which underground mining has occurred to show the proximity of urban areas to underground mines and the number of acres and estimated number of housing units that may be exposed to subsidence risk. The information will be used by IMSIF to develop a more accurate picture of the actual financial risk from mine subsidence in Illinois.

- Geochemical fingerprinting of gas emanating from a shallow-dug water well in Livingston County indicated that the mysterious gas was storage gas escaping from a nearby gas storage field. The gas company took steps to control the problem. In Champaign County, combustible gas emanating from a basement sump in Champaign County was analyzed and identified as gas coming from a leaky pipe to a propane fuel tank, not gas originating from the decay of organic matter within glacial drift.

GENERAL AND BASIC RESEARCH

Crustal Studies and Basin Analysis

- Statewide aeromagnetic and gravity maps were compiled on regional scales by the USGS in cooperation with the ISGS.

- Recent deep-reflection COCORP data, combined with aeromagnetic data, suggest that the Tennessee-Illinois-Kentucky Lineament represents a megasuture between Precambrian terrains.

- The subsidence history of the Illinois Basin has been elucidated in recent poster seminars and in articles soon to be published. An early phase of very rapid subsidence caused by rifting in the New Madrid Complex was followed by a phase of gradual subsidence; sporadic disturbances in this phase of subsidence appear to have been associated with changes in intraplate forces resulting from plate tectonics activity, including continent-to-continent collisions. A poster session presenting the tectonic subsidence history of the Illinois Basin, regional isopach maps, a gravity map and a seismic line from the Illinois Basin, and the history of the North American Plate received the Vincent E. Nelson Award for the best poster at the annual meeting of the Eastern Section of the American Association of Petroleum Geologists at Bloomington, Indiana.

- The ISGS, working with geoscientists from the Indiana and Kentucky Geological Surveys as well as from academia and industry, completed a major, comprehensive book on interior cratonic basins of the world. The profound effects of plate tectonic interactions on the evolution of supposedly stable interior cratonic basins are described in the volume. The Illinois Basin is one of seven example basins included in this volume, which will be published as one of five *Memoirs* by the American Association of Petroleum Geologists on World Petroleum Basins. A summary of the results of the volume was presented in a poster session at the annual meeting of the AAPG in San Francisco in June, and at 17 universities, research institutions, and geological societies as a part of the AAPG Distinguished Lecture series.

Geologic Mapping

- Color negatives of maps of the Creal Springs, Eddyville, and Stonefort 7.5-minute geologic quadrangles were submitted to the printer, and the map of the Goreville quadrangle was submitted to Northern Illinois University's Cartographic Laboratory for scribing and color separations. A manuscript to accompany the first three quadrangle maps was submitted to the publications unit for editing, and the report for the Goreville quadrangle is in final administrative review.

- The Illinois Senate passed Senate Resolution 881 calling for the ISGS, in cooperation with other state agencies and industry, to prepare a report on the status of geological mapping in Illinois that focuses on the needs and priorities for future geological mapping and the cost/benefit ratio of recommended programs. A task force consisting of six members of the Senate (three appointed by the President of the Senate and three by the Minority Leader) will contribute to the project.

Quaternary Investigations

- ISGS and Kent State University geologists identified an 800,000-year-old section of organic, fossiliferous silts overlying bedrock as the oldest Pleistocene sediments in Illinois. The section was found near Quincy, in Adams County.

- Research at the ISGS investigating the character and dynamics of large ice sheets and their resulting deposits was described in a paper, "Multiple Wisconsinan Glacigenic Sequences at Wedron, Illinois," published in the *Journal of Sedimentary Petrology*.

- A geologic report on the Quaternary framework of the Lake Calumet area was submitted to the State Water Survey in June for incorporation into a draft report to the Illinois EPA.

- Ardith Hansel, ISGS, and Ulpu Väisänen, geologist with the Geological Survey of Finland, began a 6-month exchange. Both scientists are contributing new perspectives on Quaternary problems in the exchange countries.

Stratigraphy and Paleontology/Palynology

- A proposed unified terminology for formations of the Pennsylvanian System throughout the Illinois Basin has been approved by the Stratigraphy Nomenclature Committees of the Illinois and Kentucky Surveys and is under consideration at the Indiana Survey. Adoption of the terminology should end the confusion resulting from the fact that different names are often used in each of the three states for many of the same formations. A paper to introduce the new unified terminology is now being reviewed by the three Surveys.

- Studies of the sedimentary features, facies relationships, and trace fossils in Late Mississippian and Early Pennsylvanian rocks continue to indicate a much stronger marine influence in the deposition of these strata than had been recognized previously. A tidal delta in the Tar Springs Sandstone (Mississippian) and paralic swamps and a seaway associated with the Reynoldsburg Coal (Pennsylvanian) were identified in conjunction with the continuing Cooperative Geologic Mapping Project in southern Illinois.

- An ISGS scientist has developed the most comprehensive palynological correlation scheme yet proposed for Pennsylvanian strata in the Illinois Basin and other coal basins in the Midcontinent, the Appalachian region, and Europe. The scheme provides a framework for comparing the coal geology in the Illinois Basin with that of the rest of the Pennsylvanian Equatorial Coal Belt in North America and Europe.

Geochemistry

- Methods perfected by the Isotope Geochemistry Laboratory to determine the radiocarbon age of groundwaters (by measuring the ^{14}C activity of the inorganic carbon fraction in the water) have greatly expanded the usefulness of radiocarbon dating of groundwater in glacial deposits. The new method, in which corrections are applied for the multiple sources of carbon based on measurements of $\delta^{13}C$, pH, and alkalinity, was first applied on water samples from the Martinsville low-level radioactive waste site.

- The Survey's Isotope Geochemistry Laboratory, which continues to be the primary lab in the state for radiocarbon dating of groundwater, has provided an additional 20 radiocarbon dates since January 1990.

Mineralogy

- Studies of the relationship between the chemical composition of chlorite and the X-ray diffraction patterns of these common clay minerals show that there are significant differences between the chlorites of the Aux Vases and Cypress Sandstones. Comparisons between computer models of X-ray diffraction patterns of chlorites and patterns of real chlorites are helping ISGS scientists refine techniques for accurately estimating the amount of chlorite in oil reservoir rocks and other materials. The type and amount of chlorite is being investigated to determine whether it is a possible source of formation damage in oil reservoir rocks.

- Bertherine, a rare clay mineral, was identified as the raw material used in a wide range of Native American artifacts from northwestern Illinois. The occurrences of artifacts suggests that the area around Sterling was the geological source, and that the mineral may have come from Maquoketa Shale.

Computer Research and Service

- A technique developed by ISGS scientists to create "slice," maps, using the GIS, provides a new tool for examining, interpreting, and publicly presenting complex geological data. Derived from the stack-unit (three-dimensional) mapping technique, a slice map displays the geology at a fixed depth interval below the ground surface. The technique is especially useful for siting and resource evaluation purposes such as locating and portraying the geologic characteristics of sand and gravel aquifers at specified depths.

- Survey researchers will be developing three-dimensional views of the subsurface geology of Illinois with the aid of the "Build Illinois" Silicon Graphics computer workstation that runs Dynamic Graphics' Interactive Surface Modelling and Interactive Volume Modelling software.

- Using a new electrostatic plotter, ISGS staff members can now produce custom-made, complex color maps from the computer databases to serve specific needs of agencies, industry, and other groups.

Several new computer workstations provide the computing power needed to manipulate large databases without the need to share the overworked central processing units of the Prime. The new electrostatic plotter was used to produce 20 copies of a map of principal aquifers of Illinois; this was the first test of the plotter for "publication" of maps.

- In cooperation with the INHS, the University Office of Telecommunications, and the Computer Services Office, the ISGS completed the installation of a building-wide Ethernet communications network that links computer resources in the Survey.

Scientific Support Services

The Quality Assurance/Quality Control program for laboratory and field procedures approved and adopted last year was implemented during the report period.

Database Enhancement

To increase accessibility to ISGS groundwater information, a format was developed for an automated groundwater database. Water-well records are being entered in this database.

TECHNICAL AND ADMINISTRATIVE SERVICES

The Technical and Administrative Services Branch Office and its Business and Financial Service Unit; Human Resource Office; Publications, Graphics, and Photography Unit; Library, Map Room, and Public Information Office; Technical Design, Operations, and Maintenance Unit; Contracts and Grants Office; and Public Liaison Office continue to provide efficient and effective support and service to the research staff and to the private, public, and government sectors, despite increased demands and workloads. Increased demands are resulting from a broadening constituency, from increases in the Survey's grants and contracts program, and from new state and federal regulations, directives, and requests. The increasing queries and requests for help and information also are a reflection of the Survey's extensive reputation for credible, scientific investigations and high-quality databases.

- The Business and Financial Services Unit improved its procedures for handling property control records, purchases, and the recovery of reasonable and allocable direct expenditures under grants and contracts. Automated monthly financial reports for the Survey's expenditures of state funds and awards under grants and contracts were expanded and made more comprehensive and useful to ISGS supervisors.

- The Grants and Contracts Office operated under an increasing load as it continued to help develop, implement, and monitor the Survey's grants and contracts program.

- The Human Resource Office handled more than 3,500 transactions related to recruiting, employment, terminations, benefits, and recorded staff inquiries.

- The Library/Map Room handled more reference questions this report period than last, while the number of acquisitions, circulations, routings, interlibrary loans, visitors, and outside phone requests remained relatively the same.

- The Information Office and Mail Room helped to distribute 31,516 Survey publications and maps and handled orders for 3,218 ISGS blueline maps and 27,993 USGS maps.

- The Public Liaison Office extended its outreach to municipal, county, and regional planners, engineers, zoning officials, governmental board members, grassroots officials, and community leaders to increase their awareness of the Survey's research and service projects of potential value to them. New exhibits were displayed at the International Geological Congress and meetings of county officials.

- The Publications, Graphics, and Photography Unit contributed significantly to the quality of the Survey effort on the volume *Interior Cratonic Basins*, to be published by the AAPG, and to multiple-board poster exhibits on this and other subjects. A large display ("Biodiversity") produced by ISGS staff in cooperation with the Natural History Survey was shown in a number of locations in Illinois. The poster display, "Tectonic Subsidence History of the Illinois Basin" won the top award at the Annual Meeting of the Eastern Section of the AAPG at Bloomington, Indiana on September 1989.

- The Technical Design, Operations, and Maintenance Unit and the Applied Research Laboratory Shop completed 460 internal work orders requiring repairs, fabrication, moving, maintenance, and other services for ISGS staff. The Survey's drill rig was upgraded, modified, and placed in operation under a trained ISGS operator. The Survey's vehicle fleet (and services for it) received a major boost this year, assuring the safety and readiness of the vehicles for Survey field work and business trips.

Educational Extension

During the year, this unit hosted field trips to four localities in Illinois. Of the 535 attendees, 163 were elementary, high school, and college students; 86 were elementary, secondary or college teachers; and 286 others represented the general public. The Educational Extension Unit also displayed major exhibits at the International Geological Congress and elsewhere and answered inquiries concerning the exhibits, the Survey, and the geology of Illinois.

Geological Records Unit

Major upgrades of the oil and gas and the water-well database were made. A backlog of 25,834 water was entered into the Survey's records system in March, some three months ahead of schedule.

Geological Samples Library

The total footage of cuttings represented by the Survey's collection now amounts to 741,954,678 feet—equal to more than 140,000 miles of drilling, or more than half the distance to the moon. This archival record of industry investments is maintained at the Survey for use by scientists and industry representatives within and outside Illinois.

Capital Projects

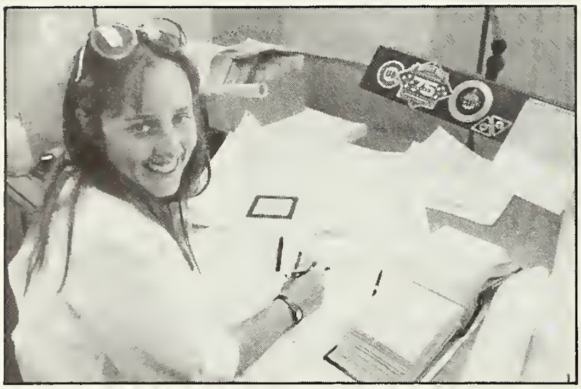
A number of analytical chemistry, geochemical, and mineral laboratories were remodeled to ensure safe working conditions and provide improved support services to Survey scientists, allied institutions, and the general public. The remodeling was part of a two-phase $786,000 renovation program initiated in FY87. A third phase, calling for a $630,000 upgrade of the remaining ISGS laboratories, was approved by the General Assembly, and funds were released for completion of the work in FY91. Work on a $308,000 fire and smoke alarm system for the Natural Resources Building was completed. The system is now operational.

Activity Measures

ISGS scientists reported 159 state-funded research and service projects and 112 sponsored research and service projects. The Survey issued 249 new reports and maps, distributed 31,516 copies of Survey publications, received or held office conferences for some 6,670 people, provided 2,065 responses to letter inquiries, gave more than 700 talks, poster sessions, displays, or interviews, and participated in almost 150 workshops, classes, and seminars. The Survey maintained an active program of information dissemination and technology transfer supporting its activities as an information center as well as a scientific research and service organization.

Mineral Resources Research and Service

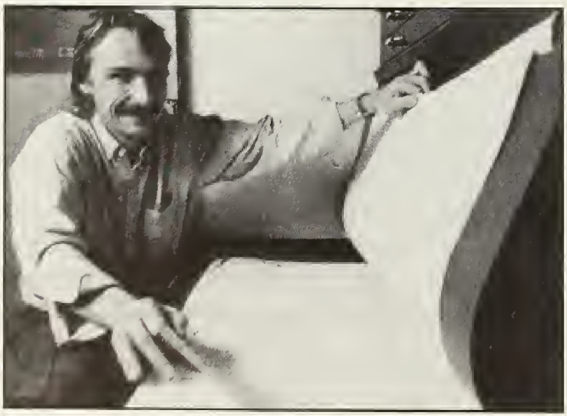
B



A

C

(A) Joan Crockett, Oil and Gas, generates a field map for the DOE project investigating controls of reservoir heterogeneity on oil recovery. (B) Subhash Bhagwat, Minerals Economics, prepares talk for the Coal Advisory Committee on fossil fuel prices. (C) Scientists from the Industrial Minerals and Metals Section help operators Vulcan Materials Company at McCook Quarry to fully use the existing aggregate materials. (D) Richard Rice, Oil and Gas, searches through oil and gas field maps for a Department of Energy project on enhanced oil recovery. (E) Stephen Whitaker, Oil and Gas, examines a geological map on the electrostatic plotter.



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MINERAL RESOURCES

ILLINOIS MINERAL INDUSTRY IN 1988 AND 1989

Illinois mineral extraction industries continued the downward trend in 1989 despite higher oil prices and a record industrial minerals production (fig.1). The total value of minerals extracted declined about 2.7 percent in real terms, although current dollar value increased 1.9 percent. Coal production increased slightly but prices fell, resulting in a 1.5 percent decline in value. The 24-percent increase in oil prices in 1989 was more than sufficient to compensate for the 8.5 percent drop in production. Sand and gravel production in 1989 reached a record level of 100 million tons as a result of continued growth in construction activity, but prices did not change appreciably (table 1).

Significant Events

- **Hanson acquired Peabody** Hanson Industries North America, the subsidiary of a British holding company, has agreed to buy Peabody Holding Company for $1.2 billion. Hanson already holds more than 45 percent of Peabody stocks. Peabody is the largest U.S. coal producer and accounts for about 20 percent of Illinois coal production.

- **Zeigler Acquired Old Ben Coal Company** British Petroleum (BP) sold its subsidiary Old Ben Coal Company, for many years one of the state's top coal producers, to Ziegler Coal Company.

- **Loss of Illinois coal market** Union Electric's Labadie plant in Missouri has contracted to buy an unspecified tonnage of low-sulfur Colorado coal to meet the new sulfur emission standards. Labadie consumed about 5 million tons of Illinois coal in 1989.

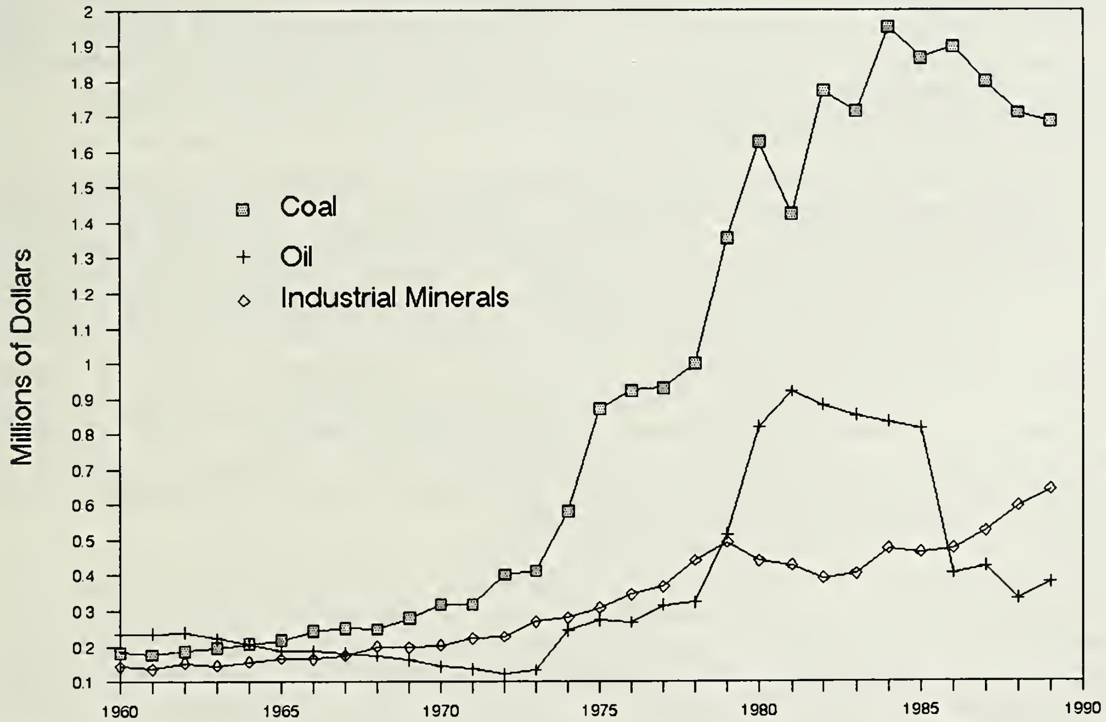


Figure 1 Value of Illinois minerals and fuels.

TABLE 1 Mineral production data for 1988 compared to preliminary data for 1989[a]

		1988		1989		Percentage of change from 1988 to 1989	
Minerals extracted	Unit	Quantity	Value ($ 1000)	Quantity	Value ($ 1000)	Quantity	Value
Fuels							
Coal	thousand tons	59,852	1,708,786	60,131	1,683,669[b]	+ 0.5	- 1.5
Crude oil	thousand bbl	22,476	332,422	20,567[b]	375,965[b]	- 8.5	+ 13.1
Natural gas	thousand Mcf	1,471	3,221	1,477[b]	3,175[b]	+ 0.4	- 1.4
Industrial and construction materials							
Stone[c]	thousand tons	59,075	251,329	61,700	262,200	+ 4.4	+ 4.3
Sand and gravel	thousand tons	34,426	149,646	38,520	164,100	+ 11.9	+ 9.7
Clay[d]	thousand tons	180	704	174	710	- 3.3	+ 0.9
Metals, gemstones and other undisclosed[e]			46,058		49,705		+ 7.9
Total value of minerals extracted			$2,492,166		$2,539,524		+ 1.9

[a] Source: U.S. Bureau of Mines and Illinois Department of Mines and Minerals

[b] Estimated by Illinois State Geological Survey

[c] Dimension stone included with values that cannot be disclosed because 1989 must be concealed.

[d] Excludes fuller's earth; included with values that cannot be disclosed.

[e] Includes fluorspar, tripoli, lead, zinc, silver, copper, peat, for 1988 and 1989 and barite for 1989.

COAL

Less than one-sixth of approximately 180 billion tons of Illinois coal in the ground—among the largest resources of any state—is considered recoverable with current mining technology and existing economic conditions. In the past decade, about 4 percent of the accessible coal resources have been recovered or rendered unminable as a result of mining. Coal resources with a low or relatively low sulfur content have been mined preferentially in the past. All current coal exploration is directed toward coal resources with a low to moderate sulfur content (less than about 2.5 percent sulfur and averaging 1.3 to 2.0 percent after cleaning). These resources are limited.

The U.S. House and Senate are working out their differences on proposed acid rain legislation. The compromise bill will likely require decreases in sulfur-dioxide emissions from a current Illinois average of approximately 5 lb SO_2/MMBtu to 2.5 lb SO_2/MMBtu by the year 1995 and 1.2 lb SO_2/MMBtu by the year 2000. To help meet these requirements, the ISGS is developing processes to remove sulfur from coal or from stack gases after combustion. Research is also focusing on removal of other undesirable elements from coal, including mineral matter, chlorine, and nitrogen-containing compounds. A process to produce high-surface-area hydrated lime that increases the effectiveness of dry sorbent injection processes for removal of sulfur-dioxide from stack gas has been developed at the ISGS. Work is also in progress on (1) chemical cleaning processes for the removal of organic sulfur from coal, (2) physical cleaning processes for the recovery of preparation plant fines, (3) pelletization to improve the marketability and burning characteristics of fine coal, and (4) studies of burning characteristics to ensure that processed coal can be used in conventional boilers.

Companies mining high-sulfur coal in the state continue to experience difficulty in marketing their product. Prior to the sale of Old Ben Coal Company to Ziegler, Old Ben had closed its No. 21 Mine in Franklin County. Zeigler has since made a decision to reopen the mine. Peabody Coal Company announced its intention to close the River King No. 1 underground mine in fall of 1989—a move putting about 300 miners out of work. The Kathleen Mine of the Cutler Coal Company went into production in the latter part of 1989; this is a punch mine into the highwall of the Captain strip mine of Arch of Illinois in Perry County of southwestern Illinois, mining the Herrin (No. 6) Coal. Consolidation Coal Company continues to hold its Wheeler Creek underground mine in Hamilton County on standby and has put its

Burning Star No. 5 surface mine (BS5) in Jackson County on an inactive status; the low-sulfur coal reserves they were mined at BS5 have been exhausted. Midland Coal Company, a subsidiary of Asarco Inc., announced closure of its last coal mine in Illinois—the Rapatee surface mine in Fulton and Knox Counties. Senior management formed the new Midstate Coal Company, which took over the operation of the Rapatee Mine at the beginning of 1990.

The longwall mining method continues to expand in Illinois. Sahara Coal Company recently installed a longwall at its No. 21 Mine south of Harrisburg in Saline County. Pinckneyville Mining Company, a newly formed subsidiary of Arch of Illinois, announced plans to open a longwall mine adjacent to Arch's Captain surface mine in Perry County. Monterey Coal Company has announced that it is seriously considering the feasibility of longwall mining at its No. 1 Mine near Carlinville, Macoupin County. Monterey would be longwalling low-sulfur coal reserves of the Hornsby area recently described in ISGS Circular 540; these reserves are located adjacent to the No. 1 Mine. Longwall mining recovers a much higher percentage of the coal in the ground than the room-and-pillar mining method that has been the standard underground mining method for many years. The initial investment is high, but the companies are rewarded by a significantly increased productivity.

Coal Database Management

Coal Stratigraphic Information System, *C. Treworgy, Coats, and Sroka* ISGS completed an FY89 contract with the U.S. Geological Survey (USGS) in March 1990 and began work on an FY90 contract with the USGS in April. Under the FY90 contract, stratigraphic data were compiled and correlated for 529 coal test holes. Copies of these data were submitted to the USGS for inclusion in the National Coal Resources Data System (NCRDS). During the current year we are compiling and correlating stratigraphic data from a minimum of 300 coal test holes. Also, samples of coal will be collected and analyzed from four mines. As in past years, these data will be entered into ISGS computer databases on coal quality and stratigraphy.

Coal Mine Information System, *C. Treworgy and Bargh* The outlines of active mines have been updated to show the extent of mining as of January 1, 1989. New county maps (1:100,000 scale) of these mined-out areas are now available. The unique mine index number used by the U.S. Bureau of Mines (USBM) is now being added to the database. This will enable the ISGS to easily access the USBM coal mine and coal chemistry databases.

A new map format that depicts the extent of the mined areas relative to surface features has been developed. The new format is based on USGS 7.5-minute quadrangle maps (1:24,000 scale) and includes color and line patterns that indicate the specific type of mining method used (high extraction room & pillar, blind room & pillar, checkerboard) and information on the completeness of the source documents for each mine: final mine map, not-a-final map, undocumented map, undated map, or incomplete map. The format is designed to facilitate the consideration of abandoned-mine hazards in land-use planning and development. Two quadrangles are nearly completed, and outside funding to support the completion of additional quadrangles is being solicited.

An event related to mine subsidence occurred in a Springfield subdivision late in September 1989 resulted in a flood of calls for information and maps of the coal mines in the area.

Coal Exploration Records, *Frankie* Coal exploration and development activity increased 19 percent in 1989. Thirteen companies filed 758 Test Hole Record and Plugging Affidavits from 15 different counties with the Illinois Department of Mines and Minerals (IDMM); 637 were filed in 1988. During the 1980s, coal exploration increased from 1,300 holes in 1981 to a maximum of 3,800 holes in 1983, then decreased to 637 holes in 1988. About 189 of the holes drilled in 1989 are far enough away from active mines to be classified as exploration holes. This is a significant increase from the 61 exploration wells drilled in 1988. Most of the drilling is developmental and located near active mines in southern Illinois. Perry, Saline, Randolph, and Williamson accounted for 514 of the wells. East-central Illinois continued to experience a renewal in coal interest. Peabody Coal Company drilled 88 development wells at the new Universal Mine in Edgar County. Consolidation Coal Company drilled 47 exploration wells in Clark County.

During the first half of 1990, the ISGS received 283 Test Hole Record and Plugging Affidavits. About 20 are exploration holes for coal mining activities. Thirty-five holes were for the Acme Brick Company's exploration of Pennsylvanian clays in Monroe and St. Clair Counties. In addition, nine holes were drilled in Monroe County by ASARCO Inc., and three holes were drilled in Hardin County by the Mississippi Lime Company for mineral exploration. The rest of the holes were related to coal mine development.

Efforts seeking release of confidential coal exploration records were rewarded. Peabody Coal Company released approximately 300 confidential coal exploration records. Additional records were released by Exxon Coal and Minerals Company, ARCO Coal Company, and the Pittsburg and Midway Coal Mining Company. Information from these records is now being recorded on Coal Section forms for entry into the computerized database and public records.

Coal Mining Geology

Coal Exploration Activity in the 1980s, *Frankie* An ISGS publication is being prepared on coal exploration activities within Illinois from 1980 to 1989. The Coal Test Record and Plugging Affidavits will be computerized. The database will be used to generate statistics and create coal exploration and development activity maps. A filing system has been set up in the Geological Records Unit. The plugging affidavits for the years 1987 to 1990 have been organized. This will be the first of a new computer-generated report series on coal exploration activities in Illinois.

Ground Stability in Partial-Extraction Mining in the Herrin Coal, *Damberger and DeMaris (ISGS); Chugh, Chandrashekhar, and Phillips (Southern Illinois University [SIU])* An open-file report covering the first year's work of this project was completed in June 1989. This ongoing cooperative study with the Department of Mining Engineering at SIU is aimed at characterizing ground conditions in underground coal mines and documenting how geologic and geotechnical information is used by the coal mining industry. A primary goal of this work is to improve the predictability of unstable roof and floor sequences in advance of mining. A preliminary system of roof and floor sequences has been developed based on lithologic characteristics. Efforts to match these sequences to reasonable stability expectations will continue during planned visits to mines in the Springfield Coal. The project is supported by the Illinois Mine Subsidence Research Program.

Geology of the Herrin Coal at Crown II Mine, *DeMaris and Nelson* A guidebook segment discussing the depositional environments of the Herrin Coal and immediate roof units was published in April 1990 in connection with the annual meeting of the Central Section of the Geological Society of America (ISGS Reprint 1990D). The stratigraphic reference section for the Herrin Coal presented in this paper is based on persistent claystone partings. ISGS research has identified a new Energy Shale facies or shale type with a distinct geochemistry.

Strike-Slip Fault at Crown II Mine, *Nelson and DeMaris* A strike-slip fault that transects this mine has been mapped. The fault appears unrelated to previously known structural features in the area. This tectonic element, unusual in the central part of the Illinois Basin, causes both roof instability and water drainage into the mine.

Coal Resources

Coal Resources of the Dekoven and Davis Coals in Southeastern Illinois, *Jacobson* These two coal seams have been mined in both southeastern Illinois and in neighboring Indiana, but their coal resources and reserves have never been assessed systematically for southeastern Illinois, except where exposed at the surface and potentially surface minable. Both coals have considerable resource potential to the north.

- **Part 1. Saline and Gallatin Counties** During the first half of the report period, maps showing overburden, exposed coal, oil fields, mined-out areas, and reliability classes were generated. The computer programs to calculate coal resources for these maps were completed and the coal resources calculated. For Saline and Gallatin Counties, nearly 2.7 billion tons of coal resources were calculated for the Davis Coal, and a little more than 1.7 billion tons of coal resources were determined for the

Dekoven Coal. In both counties, more than 4.4 billion tons of coal resources were identified. This represents a 1.3 billion ton increase over previous estimates for the two counties.

- **Part 2. Hamilton and White Counties** More than 600 drill hole records were entered into the stratigraphic database.

Availability of Coal Resources in Illinois, *C. Treworgy and Bargh* This pilot project, sponsored by the U.S. Geological Survey (USGS), is a detailed examination of the coal resources and their availability for mining within the Middletown 7.5-minute quadrangle. The quadrangle, located north of Springfield, contains resources in seven coal seams. Cultural features, competency of the overburden and interburden, coal thickness, stripping ratios, size of reserve blocks, and coal quality are major factors that may limit the availability of coal resources for mining. Evaluation of 20 to 25 quadrangles representing the range of mining conditions found in the state is planned. The findings from each quadrangle will be extrapolated to areas with similar conditions throughout Illinois.

Cooperative Research on the Springfield Coal, *C. Treworgy, Bargh, and Damberger* The Kentucky, Indiana, and Illinois State Geological Surveys compiled data on the Springfield Coal into a computer database to support interstate cooperative research. The database has been used to produce (1) a base map showing state and county lines, limit of the Pennsylvanian, and outcrop of the coal, mines, channels, and faults, (2) maps showing the thickness and depth of the coal, and (3) maps showing the sulfur and Btu content of the coal. Versions of these maps were displayed at three geological conferences. Final versions are being prepared for public distribution.

Coal Resources/Reserves Assessment, Cooperation with U.S. Department of Energy (DOE), Energy Information Administration, *C. Treworgy and Damberger* Dr. Damberger participated in an conference at the DOE/EIA offices on December 5, 1989, with coal resource/reserve experts from around the nation. They had gathered to assist DOE/EIA in planning its project to reassess the DOE's Demonstrated Reserve Base for the nation. He also participated in a meeting of the Steering Committee for the project. Colin Treworgy participated in the Coal Reserves Assessment Conference sponsored by the Energy Information Administration of DOE, February 7 and 8, 1990. Representatives from the coal industry and federal and state agencies discussed ways to improve the Demonstrated Reserve Base, an important database on national coal reserves. Mr. Treworgy presented a paper, "Using Company Reserve Estimates to Calibrate Government Reserve Base Estimates: A Test Case in the Illinois Basin." Heinz Damberger of the ISGS and Manny Eframian of AMAX Coal Company were co-authors. As a follow-up to this meeting, Illinois and other coal-producing states submitted proposals for specific projects to improve their coal resource estimates.

Measuring Coal Seam Thicknesses with Normal-Lateral Electric Logs, *Berggren* In large parts of southern and central Illinois, minable coal beds lie below the depths ordinarily reached by coal exploration and mining. Geophysical logs of oil and gas wells—particularly normal-lateral electric logs (N-L E-logs)—have been used to map coal resources since the early 1940s. N-L E-logs constitute about 74 percent of the numerous geophysical logs in the Basic Well Data File and are the primary source of coal resource data in large areas of the state where potentially minable coals lie below the ordinary depths of exploration and mining. Using the N-L E-logs to measure the thicknesses of minable coal seams penetrated by the wells has presented several continuing difficulties.

The report, "Measuring Coal Seam Thicknesses with Normal-Lateral Electric Logs" (in review), discusses the technical logging literature and several hundred N-L E-logs from central and southern Illinois in order to describe 17 thin-bed marking features of the log curves and recommend techniques for using them to closely measure coal seam thicknesses.

Coal Characterization

Spatial Distribution of Organic Sulfur in Selected Illinois Basin Coals, *Harvey, Demir, and Lowry* Knowledge of the variability of organic sulfur is needed to aid in the design of efficient processes to remove sulfur from coal. A method was developed to position an identified maceral under the beam of the scanning electron microscope (SEM) and apply standardized procedures, using the EDX, to quantitatively determine the concentration of sulfur at spots where no mineral matter was present.

The organic sulfur content of the maceral particles constituting coal proved to be variable; spot values along traverses across individual particles differ from the mean value by as much as 20 percent. The variability is highest among the inertinite macerals in five coals tested. Analysis of vitrinite, liptinite, and inertinite group macerals indicates that the organic sulfur content is generally highest in sporinites and lowest in various inertinites and intermediate in vitrinites. The organic sulfur in other liptinites (cutinite and resinite) generally ranges between that of vitrinite and sporinite in the same coal. Among the inertinite macerals in a coal, the mean organic sulfur in fusinite is lower than in semifusinite.

This work was sponsored by the Illinois Coal Development Board. Certain of the unique microscopical results were presented at the annual meeting of the Society for Organic Petrology by Dr. Demir, who later discussed other aspects in a poster paper at the annual meeting of the Geological Society of America in St. Louis, Missouri. A manuscript, based on the final report to the Board, was written and accepted for publication in *Organic Geochemistry*.

Characterization of Organic Sulfur in Macerals and Chars, *Harvey, Demir, Lowry, and Hackley* SEM-EDX methods in the project described above are being applied to characterize the organic sulfur in macerals adjacent to pyrite, both before and after charring the coal in a reducing atmosphere from 250° to 550°C. On the average, organic sulfur content increased near pyrite grains after the coals were charred at 550°C—a fact indicating that some pyritic sulfur released during charring is combined with the organic matrix rather than being emitted to the atmosphere. Sulfur isotope data generated confirmed the movement of pyritic sulfur into the macerals during heat treatment of the coals. The results of the isotope analyses of organic sulfur in sample (IBC-107), prior to and after charring, indicate that about 18 percent of the organic sulfur remaining in the 550°C chars is sulfur that was originally pyritic sulfur.

The residues from the low-temperature ashing of nine special coals were analyzed for their size distribution with a computer-controlled particle-size analyzer (Microtrac), and significant variations were noted in the size of minerals from one sample to another. The method has potential for predicting the fineness of crushing required to liberate mineral matter.

Sulfur Isotope Geochemistry of Illinois No. 6 Coal, *Hackley, DeMaris, and Cao* Recent studies conducted at the ISGS Isotope Geochemistry Laboratory demonstrated a relationship between the isotopic compositions of pyritic and organic sulfur in the Herrin coal directly beneath channel deposits. The ($\delta^{34}S$) isotopic ratio for sulfur of the pyritic sulfur in the lower half of the seam is significantly more positive than that of the organic sulfur beneath the channel areas. This observation facilitated the process of locating a coal sample exhibiting a large difference between the $\delta^{34}S$ of the pyritic and organic sulfur for the Illinois Basin Coal Sample Program (IBCSP). The coal sample collected for the IBCSP is currently being used in coal desulfurization research in Illinois as well as by researchers in other states.

Our current objective is to study the sulfur geochemistry of coal near and beneath a channel deposit to learn more about the origin of the sulfur and the reasons why a relationship is observed between the sulfur isotope geochemistry and the channel deposit. Small core samples were collected from three sites beneath, at the edge, and away from a channel deposit in the Herrin coal seam in an underground mine in central Illinois. Chemical and isotopic analyses of the samples have been completed and the data are now undergoing interpretation.

Correlations Between Organic and Inorganic Constituents in Beneficiated Coals—Possibility of Predicting Btu, Organic Sulfur, and Rank, *Kohlenberger, Lytle, and Kruse* Previously developed predictive techniques may apply to materials other than whole coals. For beneficiated preparation plant fines, theoretical values were used successfully in material balance calculations, yielding results for the composition of waste material that were nearly identical to analyses. The potential savings in laboratory analysis time is considerable.

Synchrotron X-Ray Microprobe Study of Trace Elements in Coal Macerals and Minerals, *C.-L. Chou* In collaboration with the Brookhaven National Laboratory, coal macerals and minerals (calcite and pyrite) are being analyzed for trace elements using a synchrotron X-ray microprobe. Abundances of calcium, iron, manganese, and strontium in calcite cleats or veins from the Herrin (No. 6) Coal are consistent with an origin by precipitation from present-day formation waters that are in equilibrium with the coal. The results were presented at the spring meeting of the American Geophysical Union in Baltimore, Maryland, May 29 to June 1, 1990.

Film Flotation Characterization of Illinois Coals, *Khan and Baxter* Differences in the relative wetability and floatability of handpicked samples of run-of-mine coals from various mines in Illinois have been noted using the film-flotation method developed by researchers at the University of California, Berkeley. Film-flotation partitions coal into lyophobic and lyophilic fractions based on differences of wetability. This information may be utilized in a new approach to fine-coal cleaning of Illinois Basin coal.

Coal Cleaning: Physical and Microbial

Engineering Development of Advanced Physical Fine-Coal Cleaning Technologies, *Lytle, Rapp, Kohlenberger, Kruse, and Chaven* The ISGS is helping Kaiser Engineers develop a froth flotation system under contract to the U.S. Department of Energy (DOE) to clean finely ground coal. The goal is to remove 90 percent of the pyrite while retaining 90 percent of the Btu. Using a three-stage froth flotation circuit, ISGS researchers have achieved 96-percent recovery of the Btu while rejecting 75-percent of the pyrite. The ISGS results, and most other advanced froth flotation systems tested, fell on a single flotation curve, indicating that each system had achieved the practical limits of cleaning and that the ISGS had achieved results comparable to the most advanced column flotation systems.

Column Versus Subaeration Cells for the Flotation of Fine Coal from Plant Waste, *Ehrlinger, Kohlenberger, Lytle, Keithly, Ghiassi, Kendrick, Bhagwat, and Khan* The purpose of this project is to compare flotation columns and subaeration machines for the flotation of fine coal from plant waste. Industrial support included the loan of a Deister Flotaire column cell continuous flow unit from the Deister Concentrator Company of Ft. Wayne, Indiana, and flotation feed in the form of plant waste from Kerr-McGee in Galatia, Illinois.

Results show that coal from the Galatia plant grades and recoveries are comparable to the laboratory results in the column and subaeration machines tested at ISGS. Compared to the plant coal, clean coal from the column had slightly greater ash, but a lower sulfur content; whereas the subaeration unit produced coal with lower ash and sulfur content in the two-stage cleaning.

Microbial Pyrite Suppression from Illinois Coals: Microbiology and Chemistry *Risatti and Broeren* This is the final year of a joint effort between the ISGS and Northwestern University. Our previous work indicated that byproducts in the culture media of specific bacteria wet pyrite surfaces and enhance pyrite separation from coals in physical desulfurization processes. The FY90 tasks for the ISGS portion of this project have been to (1) isolate and identify the pyrite suppressant(s) produced by specific bacteria, (2) evaluate additional bacteria for pyrite suppressing activity, and (3) provide enough bacterial supernatant for large-scale testing by the Northwestern group.

During this period we determined by column chromatography that the pyrite suppressant is a protein or protein-containing molecule with a molecular weight of about 30,000 mass units. Currently, we are resolving the compounds in the active fractions obtained by column chromatography using gel electrophoresis. To determine suppressant activity in the small volumes (about 40 microliters) obtained from the electrophoretic gels, we calibrated an induction timer for finely divided pyrite. Funding for this project came from the Illinois Coal Development Board through the Center for Research on Sulfur in Coal.

Method for Improving Sulfur Capture Using Coal/Sorbent Pellets, *Rapp, Lytle, Hackley, Moran, Kohlenberger, Rostam-Abadi (ISGS); Berger (UI-UC); and Griggs (CERL)* Modern coal mining methods have led to an increased amount of fines generation that are generally not processed because there is little market for fine coal. Disposal of fines causes lost coal sales and waste disposal costs. If a pelletization method can be developed to constitute waste fines into a clean burning fuel, the marketability of waste fines would be established.

Research to improve pellet quality and decrease overall binder costs resulted in a process called carbonation, that is, the reaction of lime hydrate with carbon dioxide to provide a bonding matrix of calcium carbonate. Results indicate carbonation improves pellet compressive strength, impact and attrition resistance, and "waterproofs" the pellets.

Combustion testing of the carbonated pellets (2:1 Ca/S ratio) indicate that sulfur captures as high as 80 percent are achievable at 850°C, the operating temperature for fluidized-bed combustors. This development could allow many high-sulfur Illinois coals to be burned at the compliance levels for SO_2 emissions (1.2 lbs $SO_2/10^6$ Btu) set for the year 2001.

Particle-Size Enlargement of Fine Coal or Char Using Lignocellulosic Residue from TVA's Biomass Program, *Ehrlinger, Kruse, Rapp, Chaven, Rostam-Abadi, and DeBarr (ISGS); Chow (UI-UC); and Strickland (TVA)* The purpose of this project is to facilitate utilization of fine coal generated during chemical cleaning, deep cleaning, or conventional coal preparation. Fine coal and fine char were mixed with lignocellulosic material from TVA's biomass program and formed into pellets. The resulting material is physically much easier to manage and has combustion properties that are, in some respects, superior to either the coal, char, or lignocellulosic material from which it is derived. The improvement is mainly due to the addition of the high volatile, low-sulfur lignocellulosic material to the fuels.

Chlorine Removal from Coal by a Wet-Grinding and Leaching Process, *C.-L. Chou, Chaven, and Demir* This project, supported the Center for Research on Sulfur in Coal (CRSC) investigated the development of a cost-effective process for removing chlorine from Illinois coal. Coal was ground to 80 percent -200 mesh, the particle size of coal burned in pulverized coal boilers. This particle size was also selected because beneficiation of coal to superclean levels requires that coal be ground to an ultrafine size for nearly complete liberation of minerals from coal. Results showed that wet-grinding coal to 80 percent -200 mesh is an effective way to reduce chlorine levels in a high-chlorine (0.42-percent) coal. The filter cake obtained by wet-grinding and dewatering contains 0.30-percent chlorine (29-percent reduction). Leaching of filter cake with tap water at 93°C for 10 minutes reduces the chlorine content to 0.21 percent (50-percent reduction).

Wet-Grinding and Selective Flocculation to Reduce Ash, Sulfur, and Chlorine Contents in Coal, *C.-L. Chou and Woodward* This project, supported by the CRSC, investigated development of a physical coal-cleaning process for removing pyritic sulfur, ash, and chlorine. A four-stage flowsheet was designed that operated sequentially: (1) crush to -10 mesh, (2) table to remove pyrite and other minerals, (3) wet-grind to an ultrafine particle size to liberate pyrite and other ash-forming minerals and to dissolve chlorine in process water, and (4) use selective flocculation to separate coal from mineral particles and chloride-containing water.

Tabling experiments showed that ash and pyritic sulfur contents could be effectively reduced. Selective flocculation has been achieved using flocculants from the Calgon Corporation, Allied Colloids Inc. (Percols), and American Cyanamid Company (superflocs). Ash reduction was found to be related to the pH of the slurry and to the dosage of the flocculant. Using a Calgon flocculant reduced the ash content in coal IBC-105 18.6 to 5.7 percent (69-percent reduction), and pyritic sulfur from 2.52 to 1.87 percent (26-percent reduction). In sample IBC-109 (0.42-percent chlorine), the high chlorine content was reduced to 0.1 percent (74-percent reduction) by wet-grinding the coal to 90-percent -20μm and by subsequent dewatering by selective flocculation. The ash content was reduced from 8.2 to 4.0 percent at 90-percent Btu recovery and the pyritic sulfur content from 0.5 to 0.21 percent (58-percent reduction).

Coal Cleaning: Chemical and Thermal

Desulfurization of Illinois Coal Using Ethanol, *Wu, Shiley, Bhagwat, Brewer, Adomaitis, and Donnals* The ethanol coal desulfurization project is a joint venture of researchers at the Illinois State Geological Survey (ISGS), University of North Dakota Energy and Environmental Research Center (UNDEERC), Ohio University, Southern Illinois University-Carbondale (SIU-C), and Eastern Illinois University (EIU). The project is pursuing two separate methods to produce a cleaner coal product. In the first method, known as the three-step process, ground coal is heated and treated with carbon monoxide. Pyrite (FeS_2) is converted to a new iron sulfide, troilite (FeS), which acts as a catalyst when the coal is treated with ethanol to remove organic sulfur (the most difficult kind of sulfur to remove). The troilite can then be treated and removed by magnetic separation.

The second method, the one-step process, is based on a different chemical procedure from the three-step process. Ground coal is heated and treated with ethanol in the presence of a "reaction accelerator."

This process, which removes both the organic and mineral sulfur in a single step, has been patented and is jointly owned by the ISGS and SIU-C.

In 1989, a partnership was established with UNDEERC to perform fluidized-bed reactor (FBR) tests of the three-step process at the 2- to 20-pound-per-hour scale. In that same year, a partnership was established with Ohio University to perform FBR tests of the one-step process at the 1- to 10-pound-per-hour scale.

Results from UNDEERC have demonstrated the mechanical ability of the three-step process to operate in a 1-pound-per-hour FBR. The equipment has now been modified to operate at 4-pounds-per-hour in both fluidized-bed and falling-bed modes. These experiments will lead to the public contract demonstration of the three-step process before November 1990. Ohio University has successfully scaled up the one-step processes into 50-gram batch equipment. These tests should lead to operation at the 1- to 10-pound-per-hour scale by November 1990.

Organic Sulfur Removal from Illinois Coal Using Perchloroethylene (PCE), *Chaven, Hackley, and Kruse (ISGS); and Buchanan (EIU)* Using the stable sulfur isotope ratio technique, we demonstrated earlier that the elemental sulfur extracted from Illinois coals with PCE at reflux temperature has its origin from the oxidation of pyrite. Extraction of the elemental sulfur from coal using PCE at a temperature higher than its boiling point in a pressurized glass reactor was tested. The results indicate that elemental sulfur in PCE extracts of IBC-102 coal did not increase with increased extraction temperature. These results confirm previous findings.

Lignin-Augmented Bituminous Coal Depolymerization (LABCD): A Route to Clean Fuels, *Kruse (ISGS); Feizoulof, Ehrlinger, and Kundson (UNDEERC); Porter (Western Research Institute [WRI]); Bourke and Uzkan (General Motors [GM]); and Strickland (Tennessee Valley Authority [TVA])* Lignin-augmented depolymerization of coal may provide coal-like solid fuels with remarkably low ash contents. Testing of Illinois Basin coals under the ChemCoal LABCD process conditions was conducted with lignin added to make up for a potential deficiency of phenolics in bituminous coal. The ChemCoal solid is believed to have fuel properties desired by GM for turbines and for diesel engines. TVA is providing lignin that is a byproduct residue from TVA's process for producing grain alcohol from wood or the lignocellulosic fraction of municipal solid waste. One lignin sample, three coal samples, and two mixtures of coal with lignin have been processed at 345°C for 45 minutes in a phenolic solvent with synthesis gas (H_2 and CO) and sodium carbonate in autoclave tests. Clean solid products having less than 0.3 wt% ash and more than 15,000 Btu/lb have been recovered from three coal tests. The ChemCoal solid produced from a mixture of IBC-109 and lignin had only 0.59-percent sulfur and would produce only 0.78 lbs SO_2/MMBtu on combustion. One pound of this material is now available for testing at Allison Division of GM.

Coal Combustion

Development of High-Surface-Area Hydrated Lime, *Rostam-Abadi and Moran* Calcium-based sorbents with high surface area are generally more reactive for sulfur-dioxide sorption. ISGS engineers have developed a proprietary process and worked on a patent application producing high-surface-area (HSA) hydrated lime. An extensive optimization study was conducted to evaluate the effect of lime properties and hydration conditions on surface-area development. The surface areas of hydrates made with commercial limes ranged from 25 to 50 m^2/g compared with areas of 40 to 80 m^2/g for hydrates made from limes prepared with the proprietary process. Hydrate surface area generally increased with increasing lime-surface area.

Pilot-scale tests were conducted to determine the efficiency of HSA hydrate for controlling SO_2 emissions from utility boilers. A 37 m^2/g hydrate with a mean particle diameter of 2 microns was tested against a 20 m^2/g commercial hydrate (made from the same lime) with a mean particle diameter of 3.5 microns. The pilot-scale SO_2 removal tests were conducted in Consolidation Coal Company's 100 KW Coolside in-duct sorbent injection process, in KVB's 146 KW boiler economizer furnace, in USEPA's 14 KW IFR unit under furnace sorbent injection conditions, and in a laboratory-scale spray drier unit located at the University of Illinois at Urbana-Champaign. The results demonstrated that the HSA hydrate removed 25 to 85 percent more SO_2 than the commercial hydrate, depending on the dry sorbent injection technology.

HSA hydrates with surface areas ranging from 40 to 60 m^2/g have been prepared in the bench-scale hydrator and are being tested for SO_2 removal efficiency in the pilot-scale dry sorbent injection test facilities.

Combustion Characteristics of Coal-Char Blend Fuels, *DeBarr and Rostam-Abadi* The reduction in the volatile matter (VM) that accompanies most thermal and chemical coal-desulfurization char-producing processes influences combustion characteristics such as ignition temperature, flame stability, and carbon burnout. To improve combustion efficiencies when firing low VM chars, the need for auxiliary fuel may be addressed by blending the chars with coal. The goal of current research is to supply a broad range of combustion characterization data on low VM chars and fuels prepared by blending the chars and parent coal.

Two size fractions each of IBC-101 coal, three chars with 9-, 14-, and 18-percent VM, and coal-char blends with 25- and 35-percent VM were studied. Devolatilization profiles of the coal-char blends showed two distinct stages that corresponded to those of the coal and the chars.

Relative ignition temperatures of fuels increased with decreasing VM and particle size. Coal-char blends gave lower ignition temperatures than their respective chars; however, for a given level of VM, the coal-char blends exhibited identical ignition temperatures regardless of the char used in the blend. Ignition temperatures of fuels with less than 14-percent VM were much higher than those of the remaining fuels.

Combustion efficiencies and ash deposition behaviors of fuels were obtained in an entrained flow reactor under conditions representative of coal-fired boilers. Combustion efficiencies increased with increasing temperature, volatile matter, and residence time and decreasing particle size. The effects of residence time and particle size were more pronounced for lower volatile fuels.

Elemental Mass Balance Studies for the Chiyoda SO_2 Scrubber at Abbott Coal Fired Power Plant, *Cahill, Henderson, and Steele* The characterization of the limestone and byproduct gypsum was completed as part of the testing phase of the sulfur-dioxide removal system at the Abbott Power Plant at the University of Illinois at Champaign (UIUC). This work was performed in cooperation with the Institute for Environmental Studies at UIUC with funding from the Electric Power Research Institute (EPRI) through the Radian Corporation. The carbonate carbon content was determined in 299 samples of limestone and gypsum to help provide data for mass balance calculations on the limestone utilization rate and to determine the purity of the byproducts of the scrubbers. Analyses for 30 metals were completed on 94 samples of various process streams using inductively coupled plasma emission spectrometry to assess environmental impacts of heavy metals. Trace-element scans indicated insignificant levels of heavy metals. A final report evaluating the performance of the Chiyoda CT-121 flue-gas desulfurization process was prepared by Radian Corporation.

Liquids and Gases from Coal

Production of Premium Liquids by Mild Gasification, *Kruse and Williams* The goals of this work were to (1) evaluate the potential of coal-derived oils to be upgraded via the H-Oil process, (2) generate material balance data under a variety of process conditions, and (3) optimize the mild gasification process with respect to the quality of the products, especially the oil. Extensive data from previous oil analyses generated were used by Hydrocarbon Research Incorporated (HRI) to estimate costs and product state of upgrade. The total upgrading cost for producing a high-quality refinery feedstock has been estimated at $24.86 per barrel.

The range of mild gasification conditions investigated in the initial experimental design was chosen on the basis of the quality and yield of products from previous research. The reaction conditions were temperature (425°, 500°, and 575°C), steam flow rate (450 and 900 ml/min at STP), and weight percent calcium oxide (CaO) added to the feed coal (0, 15, and 30 percent). A statistically designed set of 18 experiments was completed. Addition of calcium oxide had the largest effect of any parameter on the product oil's characteristics. Results indicate optimum conditions to be 500°C, with 15 wt% CaO additive and a low flow of steam (225 to 450 ml/min).

Application of Integrated Gasification Combined Cycle (IGCC) Technology Using Illinois Coal, *Lytle, Ehrlinger, Eidel, Ruch, Bhagwat, Harvey, and Kruse* Investigation of the applicability of Illinois coal for use in IGCC is required to evaluate the advantage of the higher Btu value of Illinois coal compared to western coal and that Illinois coal slurry can be pumped at a much higher percentage of solids then western coal, thereby increasing gasification efficiency. The IGCC technology includes the recovery of valuable sulfur from the gas stream as a valuable byproduct. The technology meets all present and future clean air specifications.

Preliminary discussions with industrial and state officials have resulted in (1) Arch of Illinois' delivery of a 400-ton lot of coal for a secondary burner test in the Dow/Destec plant at Plaquemine, Los Angeles, scheduled for summer 1990, (2) representatives of Arch, Illinois Department of Energy and Natural Resources (ENR), Illinois State Legislature, ICDB, and ISGS have visited the operating plant (2400 tons of western coal per day) at Plaquemine, and (3) the fact that under favorable conditions and testing, Destec would be willing to switch to Illinois coal at Plaquemine.

Technical Support Services

Illinois Basin Coal Sample Program, *Kruse, Chaven, Ehrlinger, and Hurley (ISGS); Vorres (Argonne National Laboratory)* At the suggestion of the Illinois Coal Development Board (ICDB), the Illinois Basin Coal Sample Program (IBCSP) was established by the ISGS in 1983 to facilitate comparisons of data among laboratories conducting basic and applied research on Illinois Basin coal. The ISGS and the Center for Research on Sulfur in Coal (CRSC) are closely linked to meet the goals of ENR for promoting quality research on Illinois Basin coal. Samples are selected primarily to meet the needs of coal research projects funded through the CRSC.

Two supplementary tasks, in addition to maintenance of the Coal Sample Bank and provision of samples, have been defined and proposed to CRSC. The first would prepare state-of-the art, physically cleaned coal from IBC-101 and IBC-106 for use as a starting coal for further chemical and biological coal cleaning. The second task recommends characterization of the following surface properties: internal surface area, porosity, pore-size distribution, and surface electrical charge.

Coal Technology Transfer and Information Services

Sixth Annual Meeting of the Society for Organic Petrology (TSOP), Hosted by ISGS, *Harvey* The meeting was held in Urbana, October 29-31, 1989. It attracted 58 researchers from the coal and petroleum industries, universities, and governmental agencies in Canada, France, Germany, the Netherlands, and the U.S. Twenty-six papers covered various research problems of current interest regarding organic matter in coal and oil shales. Of the papers presented as talks, 14 manuscripts were subsequently published in the proceedings of the meeting. Dr. Harvey served as coordinating editor for the peer review and submission of the papers to the international journal, *Organic Geochemistry.*

Distribution and Forms of Chlorine in Illinois Basin Coals, *C.-L. Chou* The First International Conference on Chlorine in Coal was held in Chicago, October 9-11, 1989, under the auspices of the Center for Research on Sulfur in Coal (CRSC) and the Electric Power Research Institute (EPRI), to address the problem of chlorine in coal. Dr. Chou participated in the organization of the conference and cochaired the first session, "Chlorine in Coal: Characterization and Measurement." He presented an invited paper on the distribution and forms of chlorine in Illinois Basin coals.

The distribution of chlorine in coal lithotypes and sodium-chlorine systematics indicate that two forms of chlorine occur in coal: (1) chloride ions as Na^+Cl^- dissolved in pore water, and (2) chloride ions adsorbed on the inner surfaces of micropores in macerals.

Information on Coal Mining Geology and Subsidence Potential, *Frankie, DeMaris, Bargh, and Damberger* Information was provided on historical coal mining (interpretated from mine maps), coal resources, potential for mine subsidence, and mining problems related to geology. Visitors received assistance in collecting coal or coal-related samples. More than 200 requests were handled in writing and on the phone; copies of mine maps as well as mine, field, and drill hole records were made available upon request. Records on coal occurrence, coal mines, and coal production were maintained.

Geochemistry of Sulfur in Coal, *C.-L. Chou* The knowledge of abundance of sulfur in coal of major coal basins in the U.S. and of the properties and origins of pyrite and organic sulfur compounds in coal was the topic of a paper published in the book, *Geochemistry of Sulfur in Fossil Fuels* (edited by W. L. Orr and C. M. White), No. 429 in the Symposium Series of American Chemical Society.

Recent Advances in Coal Geochemistry, Special Paper 248, Geological Society of America, *C.-L. Chou* This publication, edited by C.-L. Chou and L. L. Chyi of the University of Akron, was released in April 1990. The publication is based on a symposium organized by Drs. Chou and Chyi. Nine major articles on subjects such as peat, trace elements, sodium and chlorine in coal, ash-fusion characteristics, and acid mine drainage are authored by scientists from universities and federal and state agencies.

Abundances and Geochemical Significance of Rare Earth Elements in Coal, *C.-L. Chou* The International Conference on Trace Elements in Coal was held at Barren River, Kentucky, September 11-13, 1989. The conference provided an excellent opportunity for the participants from 11 countries to exchange information on using trace elements to solve geological problems and assessing the impact of toxic elements on the environment. Dr. Chou was invited to give a lecture on the abundances and geochemical significance of rare earth elements in coal.

OIL AND GAS

The serious short- and long-term energy problem in the United States—the inadequate supply of domestic petroleum for transportation fuels—has become apparent to many more Americans after the attention given to domestic fuel supply and demand caused by the Middle East crisis. The U.S. dependency on oil, the depressed state of the Illinois oil industry, and the potential of unrecovered petroleum resources in existing fields have all provided strong incentives for establishing an Illinois-specific, comprehensive oil and gas research program.

Recognizing these factors, the Illinois State Geological Survey is positioning itself to respond to the needs of the state and be of maximum help to the independent oil industry of Illinois. The ISGS has expanded its program of research and service in oil and gas. Its goals are to aid Illinois' independent oil producers in the recovery of higher percentages of oil from fields already discovered, develop new incentives to encourage exploration, promote wise development of Illinois' oil and gas resources, and provide complete and timely information to the oil industry.

To recover higher percentages of oil from Illinois' petroleum-producing reservoirs, it is necessary to increase understanding of the nature of the reservoirs by acquiring knowledge that will help prolong and enhance productivity. Goals of the oil and gas geosciences research program are

- define the state's remaining unswept mobile oil (currently estimated at 1.4 billion barrels);
- transfer results of otherwise unobtainable research to the Illinois independent oil producers;
- persuade stripper well operators not to abandon access to remaining oil in place;
- develop technology to enhance production from mature fields;
- prove that future reserve additions in Illinois can come from extensions to existing fields and intensive, directed development of existing fields through geologically targeted infill drilling;
- encourage renewed hydrocarbon exploration in the Illinois Basin.

The ISGS Oil and Gas Program also aims to aid the petroleum industry in exploration and development of Illinois' resources by providing the comprehensive data collection, mapping, and information from subsurface stratigraphic research on possible new petroleum targets and new techniques for exploiting existing fields and plays.

Oil and gas data are made available to the public via (1) an annual report on the petroleum industry in Illinois, (2) a monthly drilling report, (3) oil and gas development maps; (4) oil and gas pay maps (showing the geographical area underlain by oil production from individual rock layers); (5) maps showing the subsurface depths of selected strata; (6) special publications; and (7) the Geological Records Unit, which contains over 310,000 files including data from more than 140,000 oil and/or gas tests.

Oil and Gas Statistics

Annual Statistics and Records, *Huff and Black* Geological records, including well logs, are submitted to the ISGS from the wells drilled each year by industry in accordance with state law and regulations.

Number of holes reported in 1988 and 1989

	1988	*1989*
Oil and gas tests		
New hole	1,179	986
Old holes drilled deeper	NP	NP
Service wells		
New holes	89	118
Old holes drilled deeper	NP	NP
Structure tests	4	0

(NP = none processed)

The 986 new holes reported in 1989 included 404 oil wells, 33 gas wells, and 549 dry holes. Illinois ranked fifteenth in the United States in 1989 in oil production. In 1989 annual production (fig. 2) fell to 20,380,000 barrels, 9.3 percent less than in 1988 and its lowest total in 50 years. Discoveries reported included one oil field, eight new pay zones in existing fields, and 16 extensions to fields.

Illinois production in 1989 compared with 1988 (MB = 1000 barrels)

	1988 MB/mo	*1989 MB/mo*	*% change from 1988*
January	1,839	1,861	+1
February	1,821	1,505	-17
March	2,000	1,752	-12
April	1,876	1,638	-13
May	1,931	1,768	-8
June	1,971	1,706	-13
July	1,844	1,749	-5
August	1,970	1,782	-10
September	1,860	1,702	-8
October	1,790	1,757	-2
November	1,779	1,708	-4
December	1,795	1,453	-19

Improved Oil Recovery Methods and Concepts

On June 28, 1990, the U.S. Department of Energy awarded a $646,000 grant to the Illinois Department of Energy and Natural Resources for the second year of a 4-year program to determine the best methods of improving recovery of a sizeable portion of the 1.5 billion barrels of oil that remain in Illinois oil reservoirs, but that are out of the reach of current drilling methods. Illinois matched the federal grant.

Research on Improved and Enhanced Oil Recovery Through Reservoir Characterization *Oltz and staff* An integrated team of geologists, reservoir engineers, geochemists, clay mineralogists, computer experts, and an economist was assembled. Selected for analysis were twelve reservoirs in southern Illinois that produce from either the Cypress or Aux Vases Sandstone—two of Illinois' most prolific oil-bearing strata.

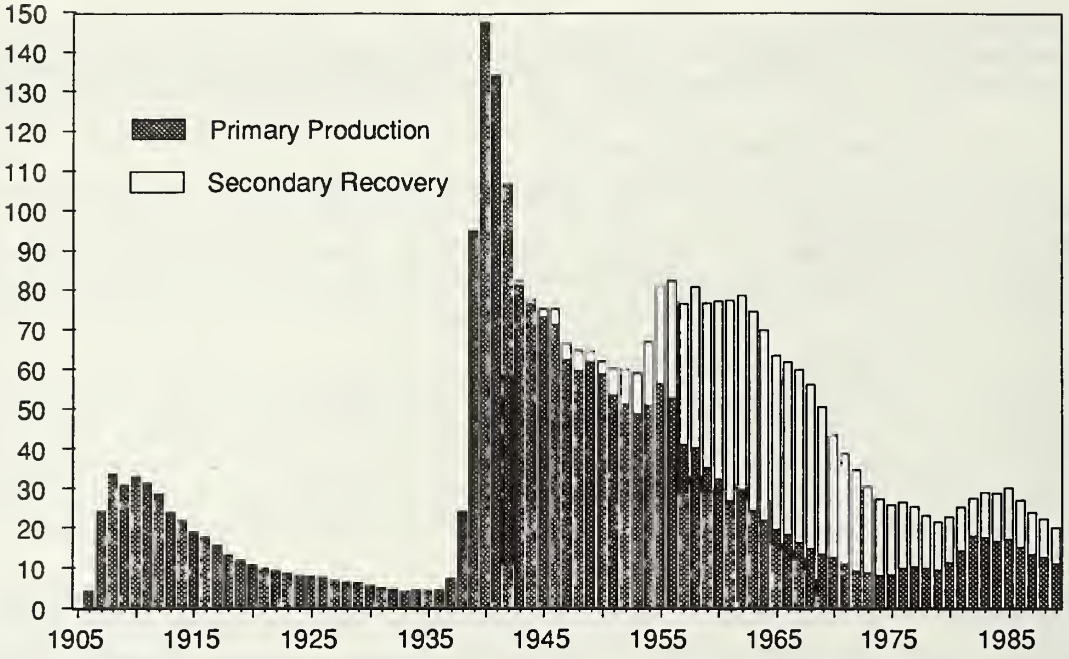


Figure 2 Yearly production of oil in Illinois.

If successful, this research program will develop techniques that maximize recovery of hydrocarbons. The ISGS will serve as a research arm for the smaller independent oil producers who are unable to undertake research on their own and who produce much of the state's oil and gas. Progress made during the first year of the research program is cited below, field by field:

Reservoir Studies

Cypress Sandstone reservoir location		*Aux Vases Sandstone reservoir location*	
Field	*County*	*Field*	*County*
Bartelso	Clinton	Boyd	Jefferson
Mattoon	Coles	Energy	Williamson
Parkersburg	Richland	King	Jefferson
Richview	Washington	Mattoon	Coles
Tamaroa	Perry	Oakdale	Jefferson
		Stewardson	Shelby
		Zeigler	Franklin

- **Bartelso Field,** *Whitaker and Finley* Cypress production is related to a combination structural/stratigraphic trap comprising four distinct Cypress sands draped over a deeply buried Silurian reef. The study has shown that the four sands are separated by marine transgressive shales. Each sand in turn contains several smaller shale layers which, in some cases, further compartmentalize the field. Preliminary findings indicate that oil recovery is influenced by this compartmentalization.

- **Energy Field,** *Huff* Energy Field produces only from Aux Vases Sandstone; it is moderately complex in geometry and lithology. The field was the target of an unsuccessful waterflood project. Recent development of the field has produced Aux Vases core that may provide insight into the cause, prevention, and remedy of presumed formation damage. Preliminary SEM work revealed that sand grains in the reservoir rock are coated with chlorite and illite clay minerals that have the potential to react with mud cleaning acid (MCA), causing formation damage that may be the cause of the production problems.

- **King Field,** *Leetaru* King Field is a combination structural/stratigraphic trap. The primary reservoir in the field, the Aux Vases Sandstone, contains three facies: channel sands, marine bar sands, and a limestone facies. Preliminary thin section, X-ray diffraction, and scanning electron microscope (SEM) work indicate that the reservoirs are well-sorted, fine-grained sands, that contain both chlorite and illite clays. The different sand bodies do not seem to be connected, and therefore, have oil at different elevations.

- **Mattoon Field,** *McGee* Mattoon Field is defined as an anticlinal trap 9-miles long and 1½ miles wide. Two hundred twenty-three electric logs have been annotated and correlated in an effort to establish stratigraphic framework, overall geometry, and lateral continuity within the Cypress and Aux Vases sequences. The logs will be incorporated into 15 cross sections that will contribute to understanding the origin and distribution of the sandstone bodies within the Cypress and Aux Vases Formations and the heterogeneous nature of the sands.

- **Oakdale Field,** *Crockett* Oakdale Field is composed of two discrete sand bodies. A small productive zone in the northeast is separated by shaly sands from a larger productive zone to the southwest. Sedimentary features noted in cores of fine-grained sandstones include abundant clay laminae associated with high-angle cross beds and a single scour or cut-and-fill structure. Presence of cross-bedded sandstone, the scour feature, and the narrow, meandering field geometry suggest the sand bodies were deposited in a subaqueous tidal channel, which may cut into underlying limestones. Reworking of sands by storms or tidal currents may be responsible for relatively clean sand accumulations.

- **Stewardson Field,** *Rice* Isopach maps and stratigraphic cross sections reveal that within the Aux Vases Formation five sandstones are separated from each other by 2 to 10 feet of shale and/or limestone. Thin sections are being prepared from Aux Vases sample cuttings and core from productive and nonproductive wells. Brine and oil from three wells in the field are being geochemically characterized.

- **Tamaroa Field,** *Grube* Tamaroa Field produces from four separate Cypress marine bar reservoirs. These bars are typically less than 10 feet thick, ¼ to ½ mile wide, and less than 2 miles long. They trend northeast-southwest and commonly stack vertically up to four separate bar cycles. Shales 1 to 10 feet thick separate the bar facies. Structural folding associated with the DuQuoin Monocline trapped hydrocarbons in the lenticular Cypress sandstones.

- **Zeigler Field,** *Seyler* Zeigler Field has produced more than 2 million barrels of oil from 26 wells in the Aux Vases Sandstone. Preliminary analysis of available core data suggests that the Aux Vases contains very good reservoir qualities: porosity is as high as 26 percent; permeability ranges from good to excellent (240 to 700 millidarcies). High-angle crossbedded sands coincide with deposition of sandbars within tidal channels that cut across tidal flats, or offshore tidal bars deposited on a shelf of green, very fine-grained, ripple-bedded, calcareous sandstone. SEM work reveals an abundance of chlorite and illite clays that are capable of creating formation damage if not properly treated.

- **Petroleum Engineering,** *Bang and Haggerty* The effects that some commonly used chemical additives have on the permeability of Aux Vases and Cypress Sandstone petroleum reservoirs is being investigated using an integrated core flow unit. Untreated oil and brine from Aux Vases and Cypress oil wells is used to simulate field conditions in the lab. The effects of different additives on core samples are being compared. Installation of the petroleum engineering lab was completed and safety and operational procedures defined.

- **Clay Mineralogy of Reservoirs,** *Beaty, Hughes, and Moore* Clastic and carbonate samples from Cypress and Aux Vases oil-field cores, selected for clay and bulk mineral analysis, were from whole and reduced core as well as from core plugs. Approximately 100 samples were analyzed in the last 6 months using an X-ray diffractometer in support of the oil and gas field studies to establish the impact of mineralogy on reservoir behavior.

- **Geochemistry of Reservoir Fluids,** *Demir* Knowledge of the formation fluid chemistry of oil fields can be utilized in understanding the lithological and hydrological conditions of the reservoir rocks. Reservoir fluid chemistry, the fluid chemistry injected fluids, and mineralogical data can be used to predict changes in mineralogy, porosity, and permeability of the reservoir rocks during enhanced oil recovery techniques. Twenty-seven brine and 20 oil samples collected from wells in eight fields producing from the Aux Vases and Cypress Formations were analyzed for their chemical compositions and attributes.

New Exploration Methods and Concepts

Tar Springs Sandstone Hydrocarbon Reservoir In Sailor Springs Consolidated Field, Clay County, *Howard* A 45-well Tar Springs oil pool is separated by 40 to 50 miles from the nearest comparable Tar Springs production. Examination of some 1300 electrical logs over a 65 square-mile area indicated that both the depositional history of the Tar Springs Sandstone and subsequent tectonic folding play major roles in hydrocarbon entrapment.

Fluvial-Estuarine Valley Fill at the Mississippian-Pennsylvanian Unconformity, Main Consolidated Field, Illinois, *Howard and Whitaker* This paper has been published as one chapter in *Sandstone Petroleum Reservoirs*, a casebook in earth sciences (Springer-Verlag). The report discusses the geologic history and economic significance of a hydrocarbon-filled sandstone reservoir deposited 300 million years ago along the floor of a 220-foot-deep valley. It can help in the search for hydrocarbons in reservoirs formed by similar geological conditions.

Application of Old Electric Logs in Analysis of Aux Vases Sandstone (Mississippian) Reservoirs in Illinois, *Leetaru* Old electric logs (from oil tests drilled before 1960) constitute a major portion of the ISGS petroleum well database. Newly developed methods of using the old logs are described in this report. These methods allow the quick and easy estimation of reservoir porosity and water saturation—two key parameters in identifying previously unidentified producing zones in older wells. The application of these methods in analysis of Aux Vases Sandstone reservoirs is discussed in a report to be published as ISGS Illinois Petroleum 134.

Source Rock Studies of the Ordovician Maquoketa Group, *Crockett, Kruge, and Oltz* Shales and sandstones of the Maquoketa in southwestern Illinois may provide a potential source-trap combinations. The sandstones may also serve as potential carrier beds for hydrocarbon migration. Biomarker analysis of some oils suggests mixing of oils from both New Albany and Maquoketa shales.

Clay Mineral Indicators of Petroleum Formation and Migration, *Moore, Hughes, Crockett, Seyler, Shaw, Glass, and Austin* Development continued on a method to differentiate clays that were physically deposited from those that chemically formed after the sediments were deposited. The latter have been shown to be indicative of the thermal conditions required for the maturation of hydrocarbons and to result from the movement and emplacement of subsurface fluids. Investigations began on the mineralogical content of the Maquoketa Group shales and the St. Peter Sandstone. The former is thought to be a potential source rock, and the latter is equivalent in age and other characteristics to strata containing recent discoveries of natural gas in the Michigan Basin.

Geochemistry of Natural Gas, *Riley, Coleman, and Liu* Natural gas samples collected as part of our oil, gas, and water well testing programs along with samples submitted by individuals and by industry are analyzed to determine their chemical isotopic composition. An occasional isotope analysis is performed. This information adds to the geochemistry of natural gas database in Illinois and is frequently used to distinguish gases from different sources and to help solve both production and environmental problems. During the report period, 58 natural gas samples were analyzed and 17 natural gas wells were flow tested.

Oil and Gas Hydrocarbon Generation and Migration Studies

Organic geochemistry of oils and source rocks in the Illinois Basin, *M.-I. Chou, Dickerson, S.F.J. Chou, and Sargent* Evaluation of the oil-source potential of the shales in the Illinois Basin is a necessary step in estimation of oil potential. The total organic carbon content was compiled for 937 shale samples from 18 counties in the Illinois Basin; the samples represent four stratigraphic intervals. Rock-eval analysis of carbon content was performed on 206 shale samples, and gas chromatography was used to determine the chemical characteristics of 83 crude oils. These data are being used to identify the sources of hydrocarbon liquids and the potential of petroleum source rocks in the Illinois Basin.

Oil and Gas Database Management

Surveywide Well Database Management System, *Yeko and Lecouris* The development of the CONQuEST Surveywide well data management system continued with the design and coding of PC and VAX production versions of the retrieval system totaling more than 11,000 lines of "C" code. The CONQuEST system now allows retrieval of all loaded data using the QuARtZ/ToPAZ retrieval programs.

- **Oil and gas records usage** A unified oil and gas database was created of 143,000 wells. This includes 40,199 wells obtained from Petroleum Information, the data for which were verified inhouse.

- **Historical wells addition** The CONQuEST system was used to enter 13,000 pre-1915 historical well records into the computer database.

- **NRIF data in digital form** Digital oil and gas well information is now available to the public.

VAX 3800 and VAX 3200 System Management, *Lecouris and Yeko* Oracle was installed on the VAX 3800 and the two VAXs were connected by an ethernet connection. System software was installed on both machines along with mapping and log display software upgrades.

Oil and Gas Development Maps Update, *Frankie and Olt* Eighty-three oil and gas development maps are on display in the Geological Records Unit for the use of the general public and industry. The status of individual wells and the geographical boundaries of oil and gas fields were updated as of January 1, 1990.

Computer-Generated Oil and Gas Development Maps, *Frankie* A project to replace the hand-drafted oil and gas development maps by computer-generated maps began. The first three computer-drawn maps will be available to the public in FY91.

OTHER ENERGY SOURCES

Coal Bed Methane and Methane from Abandoned Coal Mines, *Frankie and Damberger* About 20 requests for information on methane resources in coal beds and abandoned coal mines were answered. A review of coal-bed and coal-mine methane research activities and publications pertaining to Illinois were completed. The data were collected to prepare a research proposal for GRI funding. A paper on coal-bed methane resources was presented at the 1990 Illinois Oil and Gas Association Annual Meeting.

Methane Sample Testing Program, *Riley* At the request of various gas well producers and operators, several coal-mine gas wells have been tested for gas composition and flow rate. These gas wells were completed into abandoned (and sealed) coal mines. The coal remaining in these mines produces methane gas, and a recent series of articles in the *Oil and Gas Journal* suggests that coal gas may be a significant resource. As a result, interest in the quality and quantity of coal-mine gas has increased.

Wells have been completed into abandoned coal mines in order to produce coal-mine methane in Williamson, Franklin, and Saline Counties. The results of these operations are being held confidential. An additional company has a lease option to drill into virgin coal beds and produce coal-bed methane in southern Illinois.

GROUNDWATER RESOURCES

The groundwater resources research effort in the past year has focused mainly on (1) completing two studies—a 3-year study of aquifers in northern Illinois and a 1-year study to better define the locations of bedrock valleys throughout the state and (2) beginning two new studies funded by the Illinois

Department of Energy and Natural Resources (ENR). The first project is a 5-year study of aquifers within the Prairie Aquigroup, which includes those aquifers within the glacial deposits of the state; it will map three major aquifers that have a high potential for contamination. The second new study is a 4-year investigation of shallow bedrock aquifers, particularly those in carbonate rocks that have a high vulnerability to contamination. In addition to mapping water resources, the goal of this study is to better understand carbonate aquifers so that we can predict their productivity. These projects are part of the Illinois Department of Energy and Natural Resources (ENR) Aquifer Assessment Program.

In addition to these state-funded projects, water resource investigations are conducted under the sponsorship of local governments. A series of studies is being concluded for Kane County, including several individual municipalities. These studies involved concentrated use of geophysical exploration techniques and provided locations for test drilling for water supplies.

The service workload in groundwater resources has remained at approximately the same level as last year. Borehole geophysical services have increased significantly during the year due to the investigation for a low-level radioactive waste disposal site.

Groundwater Assessments

Regional Assessment of Northern Illinois Groundwater Resources, Avery (USGS); Chenoweth, Seaber, Cantwell, Morse, Orozco, C. Wegscheid, and Herzog (ISGS) This 3-year ENR-funded project was part of the Aquifer Assessment Program to review and digitize existing well records of the northern 35 counties and to assess the region's groundwater resources. The final draft report, which includes three reports covering the region, was delivered to the funding agency in June 1990. These reports include comprehensive aquifer information by county as well as updated bedrock topography and glacial drift thickness maps. They will be published in FY91. The final reports will be useful to planners, well drillers, and individuals interested in new or increased water supplies.

Groundwater Resources in Bedrock Valley Aquifers, *Seaber, Chenoweth, Orozco, C. Wegscheid, Cantwell, Heigold (ISGS); and Avery (USGS)* This 1-year project began in FY90 as part of the ENR Aquifer Assessment program. The goal of the project, which covered the entire state, was designed to better define valleys in the bedrock surface. Bedrock valleys commonly contain deposits that can be important sources of groundwater in scattered locations. Draft maps, which updated older bedrock topography and drift thickness maps along known bedrock valleys, were delivered to ENR this year. Final maps are scheduled to be published in FY91.

Prairie Aquigroup Assessment, *Herzog, Kempton, Anderson, Vaiden, Chenoweth, Seaber (ISGS); and Carrillo (NIU)* This 5-year project began in September 1989 as part of the Aquifer Assessment Program funded by ENR. Although the Prairie Aquigroup includes all aquifers in the Quaternary glacial deposits in Illinois, this project will first focus on a area critical for both water quality and water quantity: the Green River Lowlands, covering parts of Bureau, Henry, Lee, Rock Island, and Whiteside Counties and including extensive water-bearing sand deposits that are vulnerable to contamination. The area is heavily irrigated. Little previous detailed work has been carried out. Data gathering is underway. Northern Illinois University is a subcontractor to study the Paw Valley, which is at the northeast edge of the study area.

Upper Bedrock Aquifer System in Northern Illinois, *Larson, Seaber, Graese, Orozco, Cartwright, Herzog, and Kolata* A multiyear investigation of the hydrogeology of the important carbonate rock groundwater resource began in 1989. The rocks of the shallow carbonate bedrock are widely used as a groundwater resource in northern Illinois. They are also highly susceptible to contamination. The first area selected for study is the region underlain by Silurian-aged bedrock in northwestern Illinois. Petrographic analysis and porosity measurements of samples of cores from the ISGS Samples Library are providing the basic data that will be supplemented by detailed field mapping.

Groundwater Resources in Kane County, *Seaber, Curry, Morse, Herzog, Schneider, and Erdmann* This thorough study of groundwater resources in the glacial drift and shallow bedrock of Kane County was supported by funding from county and local municipalities and the Division of Water Resources of the Illinois Department of Transportation. The report of the project, which successfully identified aquifers with large potential groundwater supplies, was published as *Shallow Hydrogeology of Kane County,* ISGS Contract Grant Report 1990-1.

Geophysical Exploration for Potential Groundwater Resources Near Bloomington, Illinois, *Larson, Poole, Heigold, Orozco, Vaiden, E. Smith, Chillson, and Herzog* During the summer of 1989, when surface-water reservoirs were approaching critically low levels, the city of Bloomington contracted the ISGS to assist in locating possible groundwater resources. Electrical resistivity methods in the valley of the Mackinaw River confirmed the absence of large near-surface groundwater resources in that area. However, the surface of a buried bedrock valley was mapped using seismic refraction methods that located the position of the buried bedrock valley and the deepest portions most likely to contain groundwater resources. When the drought ended, the need for groundwater resources diminished. The city is now prepared, however, for rapid response should the need for groundwater arise in the future.

Hydrogeologic Investigation for a Supplemental Groundwater Supply for the Town of Normal, Illinois, *Vaiden and Kempton* Following the ISGS investigation for Bloomington, hydrologic investigations for a supplemental groundwater supply for Normal, Illinois, were conducted under a contract agreement with Normal through their consultant, Farnsworth and Wylie. The investigation indicated the area west of Normal's west well field is still considered as having the best potential for developing additional municipal groundwater supplies. Comments on the final draft report were received from Farnsworth and Wylie. Peer review and final revisions are nearing completion. The investigation will be available as an Open File Series report.

Definition of Regional Groundwater Resources in Western McLean and Eastern Tazewell Counties with Emphasis on the Mahomet Bedrock Valley, *Kempton (ISGS) and Visocky (ISWS)* A proposal was submitted in July and a contract signed in September 1989 for funding by a Joint Steering Committee including officials from McLean County, City of Bloomington, and Town of Normal to support a study to supply urgently needed hydrogeologic information to aid the officials in determining the feasibility of developing a regional water system to serve an area including western McLean, eastern Tazewell, and Woodford Counties. Among the various options being considered is developing a major groundwater supply to serve this region. The ISGS role was to supply the basic geologic framework and to map the distribution of the principal sand and gravel aquifers of the region. It also acted as coordinator for the project. The Illinois State Water Survey (ISWS) participated along with the ISGS. A draft report, submitted in March 1990, describes the geologic framework and distribution and hydrologic properties of the principal sand and gravel aquifers of the regions.

Interpretation of Geothermal Surveys, *Larson and Cartwright* Geothermal prospecting for groundwater, a method that utilizes small variations in ground temperature to locate shallow aquifers, was conceived by ISGS scientists in the 1960s. A computer model of heat and water flow in soils has been combined with field data from ISGS investigations to improve our understanding of the fundamental processes underlying these surveys. Implications for the interpretation of geothermal surveys were outlined in a doctoral dissertation submitted to the University of Illinois. Results of this research were presented at the spring meeting of the American Geophysical Union in Baltimore, Maryland, May 29 to June 1, 1990, and submitted for publication to *Geophysics.*

Shallow Groundwater Geology in Kankakee and Northern Iroquois Counties, *E. Smith* Farmers in eastern and northern Iroquois County have increased irrigation using groundwater and caused seasonally declining water levels in the shallow dolomite bedrock aquifer and problems in some local wells. This problem accentuated the need for understanding the shallow hydrogeology of the area, particularly the long-term effects of continued large withdrawals. Hydrogeologic mapping in this complex area was revised using geophysical methods. Geophysical methods were used to map the bedrock surface and to supplement information from existing well records on the nature of the glacial drift.

Water Use

Water Use Act Activities, *E. Smith, Vaiden, Brower, Cantwell, C. Wegscheid, and Herzog* Under the provisions of the Water Use Act of 1983, the ISGS and ISWS provide technical assistance to the staffs of County Soil and Water Conservation Districts by assessing the potential impacts of high-capacity water wells on the groundwater resources of the surrounding region. During the year, ISGS staff evaluated approximately 218 proposed or existing well sites to determine the hydrogeologic conditions of the area. Of the sites evaluated during this year, 117 required detailed geologic reports by Survey staff. Detailed geologic reports were completed for 56 of these sites.

Under the 1987 amendments of the Water Use Act, the ISGS and ISWS provide technical assistance to the Soil and Water Conservation Districts of Kankakee, Iroquois, McLean, and Tazewell Counties in the investigation and resolution of complaints received regarding the loss of water supply to wells in the vicinity of high-capacity water wells. No complaint resolution requests were received at the ISGS during this period.

Technical Assistance

Resistivity Surveys, *P. Reed* Resistivity (electrical) surveys are useful for interpreting the sequence of shallow earth materials and water quality above the bedrock surface. Resistivity surveys for sand and gravel aquifers were conducted at 65 problem locations where test drilling has failed to reveal an adequate groundwater supply or to assess changes in groundwater salinity. Included were studies for eight municipal water supplies, four government agencies, three public supplies, two industries, one pollution area, 17 farms and 30 private acreages in Illinois. Six letter citations were received in recognition of field assistance utilizing electrical earth resistivity surveying in the search for adequate groundwater supplies. Two were from well drillers, two from individuals, one from a proposed water district, and another from a municipality (Congerville).

Borehole Geophysics, *P. Reed, Morse, and Orozco* Borehole logs provide graphic records of the chemical and physical characteristics of earth materials. Borehole logs are the most common geophysical data used by geologists, hydrologists, and engineers. Logs are run in fluid-filled or air-filled open and cased boreholes. Borehole logs generally provide information on electrical, acoustical, or physical-chemical properties of the rocks and/or their contained fluids; they are used for aquifer evaluation and for stratigraphic analysis of unconsolidated and consolidated earth materials. During FY90, 72 borehole logs were run at 44 sites.

Technology Transfer and Information Services

Service Requests for Groundwater and Geologic Information, *Brower, P. Reed, E. Smith, Herzog, and staff* Requests for information were received from well drillers, farmers, citizens, industries, and governmental agencies desiring to locate, develop, use, and evaluate groundwater resources. Responses included approximately 1,400 phone calls, 150 letters, 126 groundwater possibilities reports, and five preliminary hydrogeologic evaluations of proposed waste disposal sites. Eighteen sieve analyses were performed for four municipal test holes and two industrial site test holes. Approximately 100 people visited staff of the Groundwater Resouces Section to seek information.

INDUSTRIAL MINERALS AND METALS

The Industrial Minerals and Metals Section conducts research and service activities related to the nonfuel mineral resources of Illinois. It is concerned with the assessment of the state's mineral resources and provides information on resources to state and federal agencies, private companies, and the general public. During the past year, major time and effort was directed toward the Conterminous U.S. Mineral Assessment Program (CUSMAP)—regional mineral assessment in southern Illinois.

An increase in nonfuel mineral activities in Illinois ocurred in FY90. A part of the increase is reflected in activities related to mergers and acquisitions. Pennwalt Chemical Corporation, parent of Illinois fluorspar producer Ozark-Mahoning Company, was purchased on January 1, 1990, by Atochem SA, chemical subsidary of the French petroleum giant, Societe Nationale Elf Aquitaine. Mining continues at Ozark-Mahoning's Annabel Lee and Denton Mines in the Harris Creek district. Mining was resumed in the Cave-in-Rock district at the former Minerva No. 1 Mine, previously acquired by Ozark-Mahoning from Seaforth Mineral and Ore Company.

Unimin, parent company of Tammsco and a major producer of tripoli in Alexander County and Union Counties, acquired Illinois Minerals Company from Georgia Kaolin, which was also recognized as a major producer of tripoli in Illinois. Active mining and exploration continues.

Rigsby and Barnard and Denny and Simpson, producers of crushed limestone in Hardin County, merged to form Hardin County Materials Company. A high-calcium limestone deposit, mined underground in the bluffs of the Mississippi River in northern Randolph County and owned by Columbia Quarry Company, was purchased by Mississippi Lime Company.

The U.S. Bureau of Mines (USBM) began a mineral inventory of the Shawnee National Forest (coal, oil and gas, fluorspar and metals, other nonfuel minerals); the inventory is scheduled for completion in 1992. The goal is to provide computer-generated resource models that can be used by the Forest Service to assess resource potential of forest land on a tract-by-tract basis. ISGS industrial minerals geologists met in Champaign and in the field with representatives of the USBM and the Shawnee National Forest to discuss the initial project, mapping of tripoli (amorphous silica) deposits on federal land in southwestern Illinois.

In other developments, interest has been heightened in mineral exploration. American Smelting and Refining Company (Asarco) conducted an exploration drilling program near Hicks Dome during the year. Geologists employed by a major domestic mining company visited the ISGS and used boring records filed with the Geological Records Unit. They indicated that their major interest is in possible sources of "specialty metals" and rare earth metals in southeastern Illinois. Four additional companies have visited the ISGS; three were assessing possibilities in the Illinois Fluorspar District, and one was planning a drilling program in or near the Upper Mississippi Valley Zinc-Lead District where mining was discontinued in the mid-1970s.

Mineral Resource Assessments

Paducah CUSMAP Project, *Eidel, Baxter, and staff* An evaluation of the mineral resource potential of the Paducah 1° x 2° quadrangle (Kentucky, Illinois, Indiana, Missouri) is being carried forward by the USGS, as part of the Conterminous U.S. Mineral Assessment Program (CUSMAP), with the cooperation of the geological surveys in each of the four states. The objective is to compile all existing geological, geophysical, and geochemical data; identify and acquire needed new information to fill gaps in the database; and complete an in-depth evaluation of the fluorspar, barite, base metal, beryllium, thorium, rare earth, industrial minerals, oil and gas, and coal potential of the Paducah quadrangle. The Paducah Project mineral assessment was rescheduled for January 1991.

During FY90, work on individual Paducah CUSMAP tasks has progressed:

- **Bedrock Geologic Maps,** *Nelson and staff* Compilation of bedrock geology was completed on a scale of 1:100,000 for each of the four ½° x 1° quadrangles that make up the Paducah 1° x 2° Sheet. These maps were digitized by staff of the Computer Research and Service Section. Editing of the computer generated maps was initiated.

- **Surficial Deposits and Stack Map,** *Berg* A digitized stack-unit map and a surficial geologic map, derived from the stack map, both on the scale of 1:250,000 were produced. The Illinois, Missouri and Kentucky portions of the Paducah Sheet were digitized into the stack-unit map computer file. Labeling of digitized polygons began.

- **Mines and Prospects,** *Baxter (ISGS) and B. Johnson (USGS)* A map and database were compiled giving the location and other information on all known mines and prospects in Illinois. This database was prepared from ISGS data, the USBM MILS listings of mines and prospects, and the USGS MODS listings prepared previously for the USGS Strategic and Critical Minerals Program. The location of approximately 270 fluorspar mines, prospects and mine shafts, mostly in Hardin and Pope Counties, were compiled on 7.5-minute quadrangle maps at the scale of 1:24,000. These maps are now being digitized by USGS personnel.

- **Subsurface Stratigraphic Studies,** *Sargent, J. Treworgy, and Whitaker* Three cross sections have been constructed to show the stratigraphic succession from surface to the Precambrian crystalline basement. The principal section starts within the Precambrian-outcrop area in the St. Francois Mountains of southeast Missouri, crosses extreme southern Illinois, and ends east of the Paducah map area in the Rough Creek Graben of western Kentucky. Two additional sections transect the area from northwest to southeast and from north to south. These cross sections will contribute to the understanding of the stratigraphic framework, structural style, and subsidence history of southern Illinois, demonstrate the relationship of major stratigraphic changes to the regional tectonic setting within the Illinois Basin, and form the framework with which to analyze the geological controls on the mineral resources of the region.

- **Lithofacies Mapping of the Eau Claire Formation in Illinois,** *Sargent* Lithofacies relationships in the Eau Claire Formation (equivalent to the Bonneterre Dolomite of Missouri) were mapped to determine whether limestone-to-dolomite transitions associated with ore deposits in southeastern Missouri also occur in Illinois. Data on the thickness of the Eau Claire were also compiled. Paleotopographic highs on the Precambrian crystalline-rock surface have caused depositional pinchouts of parts of the Eau Claire and the underlying Mt. Simon sandstone. Carbonate beds in the Eau Claire range from entirely dolomite to entirely limestone. Major lead-zinc-silver mineralization in Missouri and other localities has been found above pinchouts against Precambrian basement and at the boundary between limestone and dolomite. A paper discussing the preliminary results of this study appeared in *Field Guide to the Upper Cambrian of Southeastern Missouri: Stratigraphy, Sedimentology, and Economic Geology*, published in conjunction with the November 1989 meeting of the Geological Society of America in St. Louis.

- **Subsurface Geochemistry of Limestone Formations,** *Baxter, Masters, Eidel, Klitzing, McKinney (ISGS); Mosier and Goldhaber (USGS)* Insoluble rock residues were used for geochemical studies of limestone formations. The studies were undertaken to obtain information on the passage of metal-bearing fluids through the sedimentary rocks of the Illinois Basin and to identify potential sites of mineral deposition. An additional 33 holes were selected for study and 3,692 samples were prepared by the ISGS for solution in acid and subsequent chemical analysis of both the insoluble residue and the solute. Dissolution and chemical analyses are being carried out by the USGS in Denver.

- **Subsurface Geochemistry of Illinois Cambrian Sandstones: A Pilot Study,** *Masters (ISGS) and Mosier (USGS)* Geochemical studies in Missouri have supported the concept that the basal Cambrian LaMotte Sandstone, underlying major lead-zinc deposits of southern Missouri, served as a conduit for the transportation of metal-bearing solutions northward from the Arkoma Basin. Consequently, sandstone samples from this unit in Illinois were dissolved for analyses to determine whether similar solutions moved through them from the Illinois Basin. The solute from each dissolution step is being analyzed for trace element and heavy metal content by the USGS in a cooperative program with the ISGS. Cluster analyses of the Illinois chemical data have revealed metal trends and mineralogical associations. Mineralogical analyses on high-specific-gravity concentrates from the bulk samples, carried out at the ISGS, attempt to identify which elements are detrital and deposited with the sand and which are associated with introduced minerals deposited from ore solutions.

- **Spatial and Geochemical Relationship of the Illinois-Kentucky Fluorspar District to the Reelfoot Rift and Rough Creek Graben,** *Eidel and Baxter* The Illinois-Kentucky Fluorspar District is located above the intersection of the Reelfoot Rift and Rough Creek Graben in extreme southeastern Illinois. The Reelfoot Rift is a fault-bounded, sediment-filled trough in the deepest parts of the Illinois Basin; the Rough Creek Graben is the eastward extension of the Reelfoot Rift. Examination of the geometry and geochemistry of the fluorspar district suggests that the F-Pb-Zn-Ba ores, the major fluorspar deposits, as well as the F-Be-Th-La-Nb-Y and Ti-bearing breccia system at Hicks Dome, are rift-related. Based on initial analysis of the CUSMAP insoluble residues, it is postulated that the unique suite of minerals at Hicks Dome may have been added to a mineralizing brine system that spread laterally to the northwest beyond the reactivated rift-bounding faults. This scenario expands the area within which prospecting may be warranted. A paper summarizing this work was presented as part of a Society of Economic Geologists Symposium on Mississippi Valley-type (MVT) ore deposits at the 1989 meeting of the Geological Society of America in St. Louis.

- **Limestone Resources Maps,** *Baxter* Potential sources of limestone for crushed stone, high-calcium chemical grade stone and building stone are being compiled from existing geologic data for the four ½° x 1° (1:100,000) quadrangles that constitute the Paducah 1° x 2° map. These maps will be digitized and plotted at the scale of 1:250,000.

- **Sand and Gravel Resource Maps,** *Masters* Potential sources of sand and gravel resources are being compiled for the four ½° x 1° (1:100,000) quadrangles that make up the Paducah 1° x 2° sheet. These resource maps are being prepared for digitization from existing surficial geology maps and surficial materials stack-maps.

- **Clay Mineral Resource Maps,** *Hughes and Moore* Field notes from the Clay Minerals Unit have been plotted on four ½° x 1° (1:100,000) quadrangles that make up the Paducah 1° x 2° sheet, clay-resources base maps. A final map of actual and potential clay resources will be prepared at the scale of 1:250,000 from geological maps of the Paducah region.

- **Characteristics of Fluorspar, Lead, Zinc, and Barite Deposits of the Illinois-Kentucky Fluorspar District (Exclusive of Hicks Dome),** *Baxter* The Illinois-Kentucky Fluorspar District was characterized according to (1) deposit type, (2) regional tectonic setting, (3) regional geophysical signature, (4) depth to and character of basement, (5) igneous affinities, (6) regional zoning, and (7) associated mineralization. Vein and manto deposits were then characterized in terms of (1) host lithology, (2) local structures, (3) wall rock alteration, (4) mineralogy of ore, gangue, and oxidation products, (5) local zonation, (6) variation in deposit morphology (geometry and size), (7) age of host rocks, (8) age of mineralization, (9) fluid inclusions for determination of temperature/salinity/isotopic composition, (10) type of mineralization (fissure filling, replacement), (11) horizontal and vertical localization, and (12) grade. Regional and orebody characteristics are being used to model the fluorspar deposits to aid in the CUSMAP assessment of mineral potential.

- **Topical Studies: Hydrothermal History and Controls of Sites of Mineral Deposition in the Illinois-Kentucky Fluorspar District,** *Baxter and J. Treworgy (ISGS); T. Hayes, M.Taylor, and L.Rowan (USGS)* The ISGS is cooperating with the USGS in a topical study of hydrothermal history, mineral sequence, and stratigraphic controls of mineral deposition in the Illinois-Kentucky Fluorspar District as part of the Paducah CUSMAP Project. Dr. Rowan of the Central Minerals Branch (CMB), USGS, visited the ISGS and selected samples from collections of ore minerals from Illinois vein deposits for fluid-inclusion work. In the Illinois-Kentucky Fluorspar District, fluid-inclusion data that reveal information on the origin, composition, movement, and temperature of ore-bearing solutions have been previously obtained only on bedded deposits.

  Tasks undertaken to date include (1) detailed examination of ore horizons within the Cave-In-Rock bedded fluorspar subdistrict and stratigraphically equivalent unmineralized sections in quarries and core holes outside the sub-district to identify sedimentary features related to stratigraphic control on localization of ore, (2) collection of ore and other mineral specimens to determine sequence of deposition of ore and gangue minerals, (3) collection of samples for fluid-inclusion studies, and (4) collection of samples to attempt to date the thermal events and/or related mineralization by isotopic methods. In addition, igneous rock and samples of minerals from selected ore bodies were sampled for paleomagnetic analysis in an attempt to date intrusive and mineralization events by comparing remanent magnetism to temporal variation in the Earth's magnetic field. Laboratory analysis of fluid inclusion in fluorite (CaF_2) and sphalerite (ZnS) have been carried out at the USGS lab in Denver. These data, providing a thermal pattern for the district, will contribute to the CUSMAP assessment.

- **CUSMAP Database,** *McKay, Pool, Stiff, and Mclean* The extensive CUSMAP database of maps and tabular data are being converted into a digital format for modeling. The products of this project will include new geologic, surficial, and contoured surface maps. The USGS has contributed by digitizing all of their 7.5-minute quadrangle series maps for this region. The final database will make the Paducah quadrangle the most detailed region of digital data in the Illinois Geographic Information System (GIS).

Limestone and Dolomite Resources

Aggregate Resource Analysis, Northeastern Illinois, *Mikulic* The continued depletion of known reserves, urban encroachment on potential sites, and resistance to quarry development has resulted in an uncertain future for the economically important aggregate industry in the Chicago metrolpolitan area. This dilemma may be alleviated by expanded use of underground mining methods. ISGS has an active program to help operators utilize existing reserves in the most acceptable manner and locate new sources through a better understanding of the bedrock geology of the area. It recently completed a study and report with an accompanying cross section, based on 30 cores drilled for the SSC project and more than 100 cores drilled by the Metropolitan Water Reclamation District of Greater Chicago. The report, currently in review, will aid in planning for underground mining of aggregate sources as surface reserves are depleted or their production restricted by urban sprawl and related factors.

Inventory of Active and Abandoned Quarry Sites in Cook County, Illinois, *Mikulic* More than 250 quarries have been operated in northeastern Illinois during the last 150 years. Most have been filled and forgotten with little, if any, record of the geological conditions or nature of the fill material. This project will provide an inventory of all active and abandoned quarry sites in Cook County and determine the geological and environmental conditions at these sites. Information is currently being derived from historical sources in many state and federal institutions such as the Library of Congress. The final product will consist of detailed maps of quarry sites, geological descriptions, and history of operation and subsequent use as landfill sites. This information will aid in investigation of environmental problems, location of new quarries, development of existing quarries, and understanding of regional geology.

Clay Resources

Clay Mineral Business, *Hughes, Moore, and White* Support of clay-mineral-based industrial activity in the Illinois included consultations, analysis of samples, phone conversations, and the assembling and sending of operation-related data. A second out-of-state brick company was assisted in their plan to locate a new mine and plant in Illinois, and a review of the history, geology, and potential of Illinois clay businesses was published in the *Proceedings of the 23rd Forum on the Geology of Industrial Minerals*, ISGS Illinois Minerals 102, December 1989.

Fluorspar and Metal Resources

Intrusive Breccias at Hicks Dome, Hardin County, Illinois, *Bradbury and Baxter* Hicks Dome, located in extreme southern Illinois, is a circular, uplifted structure marked by numerous occurrences of intrusive breccia, some mineralized. Intrusive breccias at Hicks Dome are believed to have been formed by explosive release of gases from a deeply buried alkalic magma, a mechanism also responsible for approximately 4,000 feet of uplift related to the dome. Forty-five breccias bodies have been mapped in the immediate vicinity of Hicks Dome. Most are nearly vertical breccia dikes up to 10 feet wide; some are bodies of undetermined shape. Some breccia exposures are weakly mineralized; and mineralized breccia (F, Pb, Zn, Ba, Nb, Be, Ti, Th, and REE) is known to occur at depth. A report describing the physical and chemical character of surface breccias exposed at Hick Dome, the related mineralization, and modes of origin is in review prior to final preparation for publication as an ISGS circular.

Exploration Drilling Records, Northwestern Illinois Zinc-Lead Mining District, *Bradbury* Logs of exploration drilling from Northwestern Illinois exist in several formats in the Industrial Minerals and Metals Section. The specific format depends on the source (producer) of the log. The organization of the log files was inherited from the Galena Field Office of ISGS where it was used during a time of active exploration and mining. Reorganization of this information will make it more accessible to staff and the public.

Silica and Industrial Sand

Structural History, Stratigraphy and Origin of Tripoli (Microcrystalline Silica) Deposits of Southwestern Illinois, *R. B. Berg and Masters* Visiting geologist Dr. Richard B. Berg of the Montana Bureau of Mines and Geology investigated the tripoli (microcrystalline silica) deposits of southwestern Illinois in September 1989.

This 1-year study of the geology of Illinois tripoli deposits is in the final stages. Detailed mapping in the area west of Elco, Alexander County, has shown that the upper contact of the Clear Creek Chert is marked by massive chert beds. Almost all of the microcrystalline silica deposits occur in the Clear Creek Chert, but are not confined to a particular stratigraphic horizon in that formation. A preliminary study of fluid inclusions from the Clear Creek indicates that quartz overgrowths were deposited from water of low salinity at elevated temperatures, probably about 200°C. The configuration of the tripoli deposit is discordant to stratigraphic contacts and to a dissected Cretaceous or Tertiary peneplain, and thus indicates that weathering or surficial backing was not the prominent factor in this leaching. Silica has apparently been introduced into the lower Devonian formations in both the Elco microcrystalline silica district and the smaller Wolf Lake district to the north. Both districts overlie strong positive magnetic anomalies that may be attributed to mafic instrusive rocks. A hydrothermal-groundwater origin of the tripoli deposits best explains these observations.

Beneficiation/Processing

Design and Construction of a Computerized Grinding Mill, *Khan, Richter, and Witzany (ISGS); Baxter and Gurmen (University of Illinois)* A laboratory-scale tumbling rod/ball mill was constructed to investigate means of achieving energy savings during comminution of mineral products. The design incorporates a 9- by 15-inch cylindrical laboratory-scale mill, various electronic sensors, an analog to digital converter (ADC), and a personal computer (PC). Debugging and refinement of the computer program is underway. The computerized mill will allow us to critically examine and optimize energy consumption by the grinding process. The method used to electronically interface the mill with a PC was presented in a paper for the Symposium on Mining held May 14-20, 1990, in Knoxville, Tennessee.

Environmental Impacts and Mineral Resources

Shawnee National Forest: Environmental Impact Statement for 10-Year Forest Plan, *Baxter, Crockett, Damberger, Hughes, and Eidel* ISGS geologists reviewed mineral resource portions (coal, oil and gas, fluorspar and metals, other nonfuel minerals) of the U.S. Forest Service environmental impact statement and the 10-year management plan for the Shawnee National Forest. Andrew Rorick, Forest Service geologist for the Shawnee, visited the ISGS on May 31, 1990, to discuss these topics.

Technology Transfer and Information Services

Mineral Industries Map of Illinois, *Masters and Baxter* The Minerals Industry Map of Illinois (scale 1:500,000), now out-of-print, shows the location of oil fields, coal mines, nonfuel mines, pits and quarries, mineral processing plants, railroads, and pipelines. Information is now being gathered and locations plotted to digitally update the map.

Industrial Minerals Publications of the Illinois State Geological Survey, *Goodwin, Mikulic, and Baxter* Illinois Minerals 104, an annotated bibliography of ISGS publications through 1989 dealing with the industrial and metallic mineral resources of the State of Illinois, has been completed.

Exploration Activities in Illinois, 1989, *Baxter, Frankie, and Hughes* ISGS provides a brief resume of exploration activities for the annual review issue of *Mining Engineering*, a periodical published by the Society of Mining, Metallurgy, and Exploration. Exploration for coal, fluorspar, crushed stone, natural sands and gravels, tripoli, and clay minerals in Illinois during the calendar year 1989 was summarized in the May 1990 issue of *Mining Engineering*.

Proceedings of the 23rd Forum on the Geology of Industrial Minerals, *Hughes and Bradbury* The *Proceedings*, Illinois Minerals 102, was released in March 1990. The national forum sponsored by the Illinois Department of Energy and Natural Resources and ISGS was held May 11-15, 1987, and featured presentations on the industrial mineral resources of northeastern Illinois (crushed stone, sand and gravel, cement, industrial silica sand, and clay for manufacture of brick, tile and other products). Six papers were contributed by ISGS authors.

Historical Information on Stone Quarries in the Chicago Area, *Mikulic* The Illinois Department of Transportation was provided geological and historical information on an abandoned quarry near Cicero, and on its subsequent reclamation and use for solid waste disposal. A 1902 map of the quarry, discovered by Mikulic at the Library of Congress while attending the International Geological Congress in Washington, D.C., was useful in determining the extent of quarrying at or near the time of abandonment. This information helped in delineating infilled and reclaimed areas adjacent to a road construction project, and thus limited the amount and cost of drilling. Compilation of historical data of this sort is valuable for environmental assessment of abandoned quarry sites.

Field Trips to Thornton Quarry, *Mikulic* On May 10, 1990, Mikulic was a leader on a field trip to the Thornton Quarry in southern Cook County. This was part of a more extensive field trip attended by a 16 geologists working for Shell Western Exploration and Production Inc. Information was presented on the geology and paleoecology of the Silurian reef environment, as exposed in the Thornton Quarry. Similar reef structures are important oil producers. On April 28, Mikulic led a field trip to Thornton for the Chicago Academy of Science.

Abandoned Mine Shafts, *Baxter* Information concerning the location and condition of abandoned mine shafts in the Illinois Fluorite Mining District was provided to the Abandoned Mine Lands Reclamation Council (AMLRC), Marion office. AMLR is seeking to identify and evaluate potential sites for reclamation.

MINERAL ECONOMICS

Major changes in the Mineral Economics Program during the 1980s have incorporated future trends, moving toward analysis of problems and issues concerning the mineral industries and away from the previous emphasis on statistical reporting. Research has diversified—from predominantly coal-related issues to industrial minerals, oil and energy policies, strategic and critical minerals, secondary recovery of minerals, process economics, and cost/benefit studies. Reviving a tradition of the 1950s and 1960s, a state-of-the-art course in Mineral Economics was taught at the University of Illinois. Recently, the Mineral Economics Section started an important new project: estimation of the benefits and costs of geologic mapping programs. The future of the Section will also be affected by the recognition of water as a mineral resource.

Market Research

An Overview of the Illinois Mineral Industry in the 1980s, *Bhagwat* A paper presented to the ISGS Management Committee in September 1989 demonstrated that the mineral industry in Illinois has suffered major losses throughout the 1980s, despite an overall increase of 15 percent in the real gross state product (GSP). The value of mined, processed, and manufactured mineral products in Illinois declined almost 50 percent in real dollars from 1979 to 1988. The fall in oil prices in the late 1980s contributed primarily to the decline, but it was not the only factor. Coal production remained stagnant while its real dollar price declined; production of common clay dropped to insignificant levels; and the value of minerals processed and manufactured in Illinois fell rapidly. Illinois' coal consumption decreased by 25 percent because of a rapid increase in nuclear-generated electricity, especially after 1986. The coal industry is seriously threatened by the proposed acid rain legislation, which has the potential of affecting about two-thirds of Illinois' current coal production.

Illinois' oil production, which peaked at about 30 million barrels in 1985, has since fallen rapidly to a 1989 low of about 20 million barrels. The price stability of 1988-1989 was not able to reverse the decline in Illinois oil production, as the prevailing price range of $16 to $19 per barrel is inadequate for the average Illinois strip well that produces about 2.5 barrels per day.

The interest rate decline of the 1980s has generally supported a continuous increase in construction activity, and therefore, increased demand for sand and gravel and limestone. However, the prices have not increased significantly in real dollars. As a result, even the industrial minerals sector has suffered.

Threats to all sectors of the mineral industry in Illinois are serious, as the rapid decline of the 1980s indicate. Major efforts in coal cleaning, oil recovery technologies, and cost cutting in the stone industry must be undertaken in order to prevent future declines.

Analysis of U.S. Fossil Fuel Prices 1971-1988, *Bhagwat* A presentation to the ISGS Coal Advisory Committee was made in May 1990. Energy thinking in the U.S. in the past two decades has been strongly influenced by the oil-price-and-supply situation, although nearly 60 percent of energy is supplied by sources other than oil. Energy policy statements in recent history have always begun with a reference to oil even when the immediate context was coal, natural gas, nuclear energy, or any of the new alternative energy forms. The implicit assumption has been that oil prices must raise prices of other fuels, and thus, an oil crisis must lead to an energy crisis. In the 1971-1988 period, coal prices were not influenced by oil prices but by the events in the U.S. coal mining industry and the world steel industry. A major reason for the insulation of coal prices from the prices of oil or gas was the availability of nuclear electric energy, which substituted for oil and gas in electricity generation. In the near future, nuclear electricity will not be available in the U.S. in the same amount as in the recent past. Therefore, coal use in electricity generation may increase as demand for electricity increases. Coal consumption increased as coal prices fell with time. Gas consumption, on the other hand, declined as prices rose over time. Oil prices, by comparison, showed at least five clear phases of price stability, price increases, and price declines, while demand went up and down. Many market-distorting regulations were removed by the end of the 1970s, so that the fossil fuel markets in the 1980s were freer than in the previous decade. As a result, price changes in oil in the world appear to react to changes (or perceived changes) in demand and supply in a more normal fashion than before. Future energy-related policies should, therefore, be more carefully tailored to fit the individual fossil fuel markets and should be less influenced by the oil psychology.

Extraction Research

Factors Determining the Economic Feasibility of Reprocessing Coal Beneficiation Wastes, *Bhagwat, Khan, and Baxter* Coal beneficiation waste can be classified into waste gob, consisting of mostly noncombustible materials containing up to 10-percent combustibles, and waste slurries, containing an average 40- to 55-percent coal fines. In Illinois, about 3 million tons of coal is lost annually in slurries disposed of by coal-cleaning plants. The lost coal represents not only an environmental problem but also an economic loss and a waste of a valuable resource. In a previous study it was demonstrated by the authors that, in Illinois, the coal fines could be profitably extracted using currently available technologies under certain conditions. In this paper, the authors describe and discuss the factors that determine the economic feasibility of reprocessing slurries. The goal was to offer prospective entrants into the business of secondary coal recovery a means of analyzing available technology.

Because coal prices have not changed appreciably in the decade of the 1980s, the product price represents the most constraining of all factors. The price is further influenced by the sulfur, ash, and Btu value of coal produced and the ability to secure stable, long-term sales agreements. Further constraints can be encountered in the regulatory climate requiring land reclamation if existing abandoned slurry ponds are targeted for coal recovery. The results of the earlier research supported by the Illinois Department of Energy and Natural Resources were presented at the International Symposium on Biohydro-Metallurgy in Jackson Hole, Wyoming, August 13-18, 1989.

Applied Economic Research

Costs and Benefits of Geologic Mapping Programs, *Bhagwat* Under a mandate of the Illinois legislature (Senate Resolution 881), an effort has been started to develop a methodology for the estimation of costs involved in geologic mapping and to assess the economic benefits of mapping programs. Little work has been undertaken previously in the area of cost/benefit analysis of geologic mapping. What exists is limited to well-defined single-purpose maps. Various methodologies for a cost/benefit analysis have been reviewed. A case study in Boone and Winnebago Counties will concentrate on one use for geologic maps, for example, to map groundwater resources; and it will develop a methodology for cost/benefit analysis. If time permits, other uses such as groundwater protection, sand and gravel and stone resources, and geologic hazards will be included.

Technology Transfer and Information Services

Illinois Mineral Industry in 1987 and Review of Preliminary Mineral Production Data for 1988, *Samson and Bhagwat* The summary of this report was presented in the 1988-1989 Annual Report. The final version has now been published as Illinois Mineral Notes 101.

Illinois Mineral Industry in 1988 and Review of Preliminary Mineral Production Data for 1989, *Samson and Bhagwat* The total value of minerals extracted from the ground, processed in the state, and manufactured into products in 1988 is estimated to have declined slightly from that of 1987. The extraction industry in 1988 showed a decline in total value by about $228 million, but the processing and manufacturing sectors made up for the loss, leaving total value unchanged at about $3.2 billion. Considering inflation, this equates to a 5-percent decline in real value. The main losses came from a drop in oil production and price per barrel. The 1988 oil production was about 1.6 million barrels lower than in 1987, the third consecutive decrease since 1985. Oil prices also declined to an average of $14.80 per barrel in 1988 from $17.50 in 1987. Similarly, coal production fell nearly 900,000 tons in 1988 and average price declined by $1 per ton. A reverse trend was shown in the production and value of industrial and construction material, which both increased significantly; metals held their own. Preliminary 1989 data suggest that the mineral industry may have performed at close to its 1988 level with an improvement in oil price but a further decline in oil production and a slowdown in construction and industrial activity.

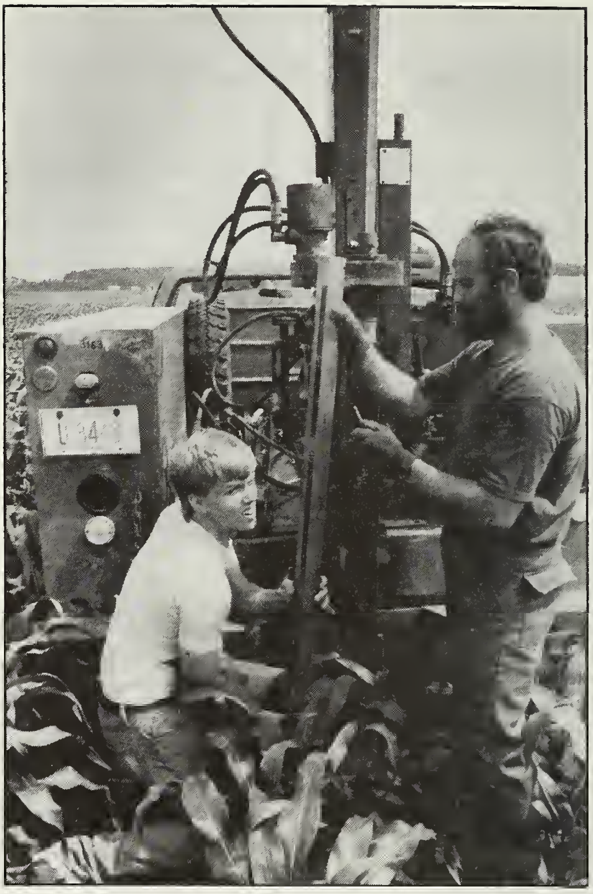
Mineral Economics Course for Engineering Students at the University of Illinois, *Bhagwat* The manuscript for the course in the Material Sciences and Engineering Department of the University of Illinois was first developed in 1988. It underwent a major expansion and revision prior to teaching in the fall of 1989. Chapters on mining, beneficiation, and production cost theory were added, and many of the other 15 chapters were revised.

Directory of Illinois Mineral Producers 1988-1989, *Samson and Masters* The directory has been published as Illinois Minerals 103. Initial response to the revised directory has been positive.

World Energy Situation—How it Concerns Illinois, *Bhagwat* A talk was given in February 1990 at the invitation of the Urbana chapter of the Izaac Walton League. A comparison of U.S. with Germany and Japan indicates that the U.S. is much more energy self-sufficient than the other two major industrial powers in the world. There has been a generally greater reliance on nuclear energy throughout the industrial world during the 1970s and 1980s as oil prices increased. As a result, the coal industry did not grow as much as it could have. The U.S. dependence on imported oil is widely exaggerated as the main cause of the nation's foreign trade deficits, which result mainly from low exports of manufactured goods. Illinois' energy situation differs from the U.S. or the world situation in that Illinois' coal industry did not benefit from the overall, albeit moderate, growth in the world and U.S. coal industry. The causes for this difference were both economic and environmental. Near-term supplies of coal reserves are not an issue in Illinois; however, the availability of coal reserves that comply with current market requirements is a major issue in the future of Illinois' mining industry. In the areas of oil and nuclear energy, Illinois developments were similar to the U.S. developments.

Environmental Geology and Geochemistry Research and Service

A



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(A) Donald McKay, Computer Research & Services, leading a field trip for the Intergovernmental Solid Waste Disposal Association of Champaign County, discusses types of material that would be poor choices for a landfill. (B) Donald Keefer, Groundwater Protection, and Thomas Bicki, University of Illinois agronomist, monitor pesticide leaching at a tile drain field. (C) Christine Fucciolo, Lake Michigan Coast and Basin Studies, and Matthew Riggs, Computer Research & Services, examine slides of the Lake Michigan shoreline. (D) Myrna Killey and Brian Trask, Environmental Studies & Assessment, describe the geology of an area south of Urbana to the Intergovernmental Solid Waste Disposal Association of Champaign County. (E) Michael Chrzastowski, Lake Michigan Coastal and Basin Studies, evaluates sidescan sonar records of the underwater conditions of shore defense structures along Chicago's lakefront.

ENVIRONMENTAL GEOLOGY AND GEOCHEMISTRY RESEARCH AND SERVICE

Environmental problems have always challenged the people of Illinois as they resolved their needs for food, water, and shelter. Archeological records of early Indians indicate that this has never been an easy task. Landslides, floods, earthquakes, and other natural phenomenon threatened lives and property then as today. To alleviate food shortages and avoid contamination from disposal of wastes, the early inhabitants of the region simply moved periodically. Today, our challenges are similar, although our responses differ vastly.

Scientists at the Illinois State Geological Survey identify and investigate the occurrence and extent of environmental risks and hazards associated with natural phenomena to help citizens and their governments plan for eventualities and decide how to protect the environment and prevent pollution, yet make the most of the state's energy, industrial, and agricultural resources. The environmental geology and geochemistry program utilizes the knowledge of ISGS scientists, the comprehensive database, and the new information gathered during studies in critical areas to provide decision makers and others with timely geological and geochemical information.

The ISGS assists in assessment of conditions for siting facilities and planning county or regional development. Contined research addresses the impact of natural and human-induced forces on the shoreline of Lake Michigan, rivers, backwaters, and wetlands of Illinois. Ongoing hydrogeologic investigations are designed to protect groundwater for future generations. Basic research on hydrologic processes enables the ISGS to contribute to legislation dealing with contaminant transport and waste containment, and to input valuable expertise to agencies responsible for groundwater protection and waste management. Environmental issues raised by mining and construction in Illinois are being resolved through research at the ISGS. Natural earth hazards, such as earthquakes, are also receiving attention. Developing a reasonable perspective on these and other hazards resulting from natural phenomena and human use of earth resources is the main focus of environmental geology and geochemical research and service.

ENVIRONMENTAL STUDIES AND ASSESSMENT

The Environmental Studies and Assessment program assesses the geologic capacity of areas within Illinois to support specific land use. Local, state, and federal agencies and industry interact with ISGS scientists to identify potential sites for location of facilities, conduct environmental impact studies, and evaluate the changing nature and uses of the landscape where natural resources have been altered by mining or other activities. Activities this past year included completion of studies that added value to the information collected during the Superconducting Super Collider (SSC) investigation, the development of a Preliminary Environmental Property Assessment Program for the Illinois Department of Transportation (IDOT), and continuation of the Lands Unsuitable for Mining Program (LUMP) in cooperation with the Office of Surface Mining and the Illinois Department of Mines and Minerals.

Special Siting Studies

Value-Added Effort in Conclusion of the Superconducting Super Collider (SSC) Program, *Gross, Kempton, Schneider, and others* An effort to consolidate the information gained during the ISGS studies involving the SSC and provide it in a form most useful to the state and its citizens was essentially completed. The valued-added goals that were designed immediately following termination of the quest for the SSC site were as follows:

- Organize all data into a useful format so that statewide databases are enhanced at the highest reasonable level. Special geotechnical and geologic reports on the bedrock and surficial materials will allow for applications to construction of roads, foundations, buildings, landfills, and other issues.

- Consolidate the water well records of the Illinois State Geological Survey and Illinois State Water Survey; ensure reliability and conformity of the data sets.

- Update groundwater resource studies for specific areas covered by the SSC study as well as provide new reports for the groundwater resources of the general region. Specifically, the report being prepared on the hydrogeology of the Maquoketa and Galena-Platteville Formations has implications for regional resource development and protection along with usefulness should upgrading Fermilab ever require a tunneling solution.

- Refocus the data toward a Geology-for-Planning project to ensure optimum use and applicability. This use of SSC information for planning purposes in this rapidly expanding area is extremely significant. Data are being used to (1) protect and manage groundwater resources, (2) locate areas with geologic materials capable for land application of waste water, (3) suggest possible reservoir locations, (4) identify geologically capable sites for solid waste disposal and (5) update and reevaluate aggregate and dolomite resources.

- Use and evaluate state-of-art technology for the interpretation of seismic data and the inspection of proprietary data not only for the immediate area of the SSC but elsewhere in the state.

- Produce reports that focus on the geology and environment of the area and the capacity and suitability of the geology for various uses. This positive approach to the wealth of data will encourage uses beyond those anticipated by the siting of the SSC.

- Provide a complete record of both the data and the process followed in the collection and presentation of that data by cataloging, sample preservation, and the assembly of archival information now available to the public.

In the spirit of the amended contracts with the Illinois Department of Energy and Natural Resources, the goals outlined above and the tasks delineated were essentially met. The production of final detailed reports will occur in 1990 and 1991 as the formal review process is completed.

Reclamation Along the SSC Seismic Lines, *Berggren* The high-resolution seismic work done by a contractor to study the rock structure for the proposed SSC ring required drilling very closely spaced holes in four lines totaling nearly 17 miles in length. Because all or parts of the four lines were drilled in ditches beside public roads, the ISGS took extra care to see that the holes were properly back filled. A program was initiated to periodically inspect the lines and to backfill partially filled holes or those having settled fillings. Inspection this year indicated that the hole fillings in two lines have stabilized and the lines can be abandoned. The remaining two lines will require inspection next spring.

Environmental Impact Studies

Environmental Property Assessments for the Illinois Department of Transportation (IDOT), *Bauer, Schneider, Erdmann, Miller, Gastineau, Summers, Adams, Bannon, Barclift, Dixon, Enloe, Hart, Morse, Rimmer, Trask, Trent, and Swick* This year our Environmental Property Assessment program for IDOT concentrated on developing procedures, evaluating methods, and organizing an effective program to perform preliminary environmental site assessments on property that has been or will be acquired for IDOT and that may contain natural and manmade hazards.

Preliminary site assessment includes the investigation of current and past land uses through a review of historical documents and data from computerized geographic information systems; onsite inspections; limited field analyses of soil, water, and air using various photoionization devices and gas chromatography; and report preparation using information from the above investigations in addition to available geologic, hydrogeologic, and other background data. During this reporting period 148 requests were received from IDOT and 94 were completed, covering 235 miles of roadway.

Laboratory Analysis of Soils for Environmental Property Assessments for the Illinois Department of Transportation (IDOT), *J. Frost* Analyses in the laboratory were completed on 26 samples collected at four sites assessed for natural and manmade hazards for IDOT. The samples were analyzed for ash content; and As, Ba, Cd, Cr, Cu, Fe, Ni, Pb, and Zn were determined by atomic absorption spectroscopy, neutron activation analysis, and energy-dispersive X-ray fluorescence analysis. The As, Cr, Cu, Pb, and Zn contents of these samples had been determined in the field using a portable X-ray fluorescence analyzer. The instrument was under evaluation for field testing of metals in surficial materials. The five elements were not measured correctly, even semiquantitatively, by the portable analyzer. Probably the number of standards used to calibrate the analyzer was not adequate for establishing curves for accurate analysis of unknown samples.

Illinois Lands Unsuitable For Mining Program (LUMP), *McKay, Krumm, Pool, L. Smith, Taylor, Witzany, and Stiff* This program, funded by the U.S. Office of Surface Mining (OSM) through the Illinois Department of Mines and Minerals (IDMM), has two principal objectives: (1) to provide information and scientific expertise to the Lands Unsuitable petition process via the preparation of land reports on the impacts of surface coal mining on the natural resources of Illinois, and (2) to assemble and maintain a detailed GIS database of coal mine permit areas to support the IDMM Mine Permit Review program.

Knox County Land Report (LUMP), *McKay, Pool, Krumm, L. Smith, Taylor, Stiff, Witzany, Denhart, Junkins, and Helm* For the first time since 1983, a Lands Unsuitable petition was filed with the Illinois Department of Mines and Minerals (IDMM). In accordance with provisions of the Illinois Surface Mined Land Conservation and Reclamation Act, the LUMP team (approximately 25 individuals from five separate divisions of the Illinois Department of Energy and Natural Resources) prepared a land report for a ten-square-mile area of southeastern Knox County. The petition alleged negative impacts on groundwater, soil productivity, tax base, and historic structures. The land report evaluated such impacts and provided a factual inventory and analysis of impacts on other natural and cultural resources. ISGS personnel used the computerized Geographic Information System (GIS) to prepare information on the geologic resources of the area, including maps of coal resources, reserves, and recoverable reserves, coal depths, water well locations, surficial deposits, mined-out areas, bedrock topography, and drift thickness. Mid State Coal Company provided records of the more than 1,200 wells and other map information used. The ISGS LUMP team worked with staff of the Coal and Groundwater Resources Sections to complete its sections of the land report. The report includes 21 maps and one cross section produced with the assistance of the GIS.

Mine Permit Review Project (LUMP), *Krumm, Pool, Taylor, L. Smith, Witzany, McKay, Graettinger, and Ploetz* Computer Research and Service Section (CRSS) personnel provide interdivisional coordination (with ISWS, NHS, ISM, and ORAP) of a major project for the compilation and automation of a database of surface and underground coal mine permit areas in the state. The GIS database is used directly by IDMM staff in their Springfield and Marion offices to review mine maps and data for permit applications and renewals. Mine operation maps, well data, land-use, and other information are entered directly into the GIS from maps supplied by coal operators with permit applications. In a concentrated effort to input information for every permit in Illinois, maps for 105 surface and underground mine permit areas were added to the database in the period between July 1, 1989 and June 30, 1990. The mine permit database now contains 174 surface and underground mines and carbon recovery facilities in 24 counties. CRSS personnel also developed and provided menu-driven software interfaces to facilitate use of the data by IDMM mine inspectors and others.

PSTRAT Well Information Database (LUMP), *Graettinger, Helm, Witzany, and C. Treworgy* The CRSS has completed the development of the well data system for coal mine permit areas and turned over the data files created by the project to the Coal Section for incorporation into their STRAT database. The automated database includes several thousand wells from Perry and adjacent counties in the southern Illinois surface coal mining region.

Engineering Assistance Studies

Stratigraphic Assistance Related to Construction of a New Navigational Lock and Dam on the Ohio River, *Masters and Norby* Loren Christman (Geotechnical Branch Office, U.S. Corps of Engineers, Louisville, KY) contacted the ISGS regarding the stratigraphy affecting the Corps' continuing evaluation for a new lock and dam site on the Ohio River near Olmsted, Illinois. The ISGS received a 2-foot segment of core from a 70-foot-section of dark shale encountered at the bedrock surface in a core hole drilled on the north bank of the river where bedrock is overlain by alluvium and the McNairy (Cretaceous) Formation. The shale was visually identified as New Albany Shale. An attempt to recover conodonts, fossils that permit detailed age determination and stratigraphic correlation, was unsuccessful.

GEOLOGY FOR PLANNING

Geology for Planning studies are designed specifically to provide geologic and hydrogeologic information at a scale useful to county agencies for resource identification, environmental management, and economic development. These studies are conducted at various levels, sometimes with specific emphasis, to meet both short and long-term needs of the community.

County Studies

Kane County: Resource-Based Land-Use Planning, *Schneider, Trask, Morse, and Erdmann* Continued work in Kane County is based on a three-phase program begun in August 1989 to develop a comprehensive geology-for-planning report for Kane County. Phase I focused on new data acquisition including subsurface data from a drilling program designed to collect new samples and provide downhole geophysical information. Most of this data acquisition phase has been completed with a few sites remaining to be drilled. Phase II is well under way and the interpretation of data and development of maps for land-use planning is the focus. Phase III centers on incorporating the data into an electronic database, coordination with Kane County planners for the use of the data, and final report writing. This study is expected to be completed during mid-to-late 1991.

Perry County, Coal Mining, *Berggren* Work in Perry County continues to build a geologic base of information useful to coal mine operators, public officials, and interested citizens involved in long-term planning for coal development in Perry County, the leading coal-producing county in Illinois. Key logs have been compiled for each township in the county, and cross sections of the townships are being constructed to facilitate the identification of major stratigraphic units and the drafting of structural maps. Herrin Coal data have been tabulated and plotted for six townships. This information will be available as an Open File Series report.

LAKE MICHIGAN COAST AND BASIN STUDIES

The Illinois State Geological Survey has been mapping and evaluating characteristics of the beaches, shallow lake bottom, and shore structures along the entire Chicago shore. In 1986, Lake Michigan rose to record levels, causing damage over much of the Illinois shore. From November 1986 through the summer of 1988, however, the Great Lakes experienced the driest period of the past 85 years. Consequently, lake levels in Lake Michigan fell more than 3 feet. Rainfall subsequently returned to normal and by winter 1990, lake levels began to return to long-term average levels. The respite from high levels gives only measured relief, however, because areas of shore have been so weakened that major storms, even at present low levels, cause damage. Agencies and private owners view these years as a time to rebuild for the next cycle of high levels.

The Chicago lakefront has severe problems. Massive revetments, beyond their design life and without maintenance for years, are in a state of disrepair. Public agencies have instituted programs for mitigation and capital improvements as funds have permitted but they face a program costing many millions of dollars. Of approximately 25 miles of Chicago shore, nearly half (11 miles) are in need of immediate mitigation. An additional 5 miles will probably require attention in the near future. North of Chicago, communities and private owners have conducted an intensive shore protection program.

ISGS research activities have been mainly supported through a cooperative agreement with the U.S. Geological Survey (USGS) Branches of Atlantic and Pacific Marine Geology. Major emphasis has been placed on monitoring shorelines, compiling and adjusting historic shore recession maps, and providing base maps.

Southern Lake Michigan mapping initiatives received $105,000 in mid-1990 from the federal Dingell-Johnson fisheries program, passed through the Illinois Department of Conservation. The initial program, "Littoral Zone Habitat Classification and Mapping of Illinois Lake Michigan Coastal Areas," was designed to be a 3-year study. During the first and part of the second year, the program will be almost entirely devoted to surficial mapping of the shore and bottom in the littoral zone. The second and third years will be spent translating the mapped areas into an ecological classification.

The ISGS participated in a joint research project to map and sample 8,000-year-old tree stumps discovered by a team of divers and salvage operators in 80 to 85 feet of water 15 miles off Chicago's lake front. This project was a cooperative effort involving the original diver-discoverers, Northeastern Illinois University (Department of Earth Science), the ISGS, and the USGS Branch of Atlantic Marine Geology.

North Point Marina, the largest state facility of its kind in the U.S., continues to occupy a prominent position in the program. The beach and nearshore areas marginal to the marina continue to adjust to the construction of this facility. The site offers an excellent field laboratory to investigate the effect of the marina on erosion, deposition, and other local coastal processes.

Lake Michigan Database Development

Aerial Photographs of North Point Marina, *Terpstra and Fucciolo* On August 25, 1989, a high- and low-level aerial photo flight was made over the North Point Marina area in Lake County to supply new shore recession diagrams for the Illinois Department of Conservation (IDOT), Kudrna & Associates of Chicago, and Moffatt and Nichol Engineers of Long Beach, California.

Status and Quality of Illinois Lakeshore Base Maps, *Jennings, Terpstra, and Matthews* Base maps, originally used for lakeshore and nearshore studies, were derived from 7.5-minute quadrangles digitized into computer programs. After computer acquisition, details from selected 1:2400- and 1:3600-scale aerial photographs were digitized onto the bases in full knowledge that mapping standards for a 7.5-minute quadrangle leaves much to be desired when maps are converted to larger scales. Horizontal errors up to 40 feet were noted. In utilizing base maps for plotting such data as for bluff erosion, an error of a few feet is significant. Even though ISGS has a voluminous file of high altitude aerial photos at scales of 1:9600 and 1:14,400, most have never been rectified (adjusted for errors in scale, distortion or flight irregularities). In view of the foregoing, a study of map inaccuracies and field techniques was conducted during the winter and spring in anticipation of receiving instrumentation that will permit improvement in base map quality through quality land surveys. Resurvey of the shore began at North Point Marina and continued south to Waukegan Harbor. A second survey of the Belmont-Montrose Harbors and Monroe Harbor areas was conducted during May and June.

Aerial Photography of the Illinois Lake Michigan Shore, May 1990 *Jennings, Terpstra, and Dexter* On May 7, 1990, a low-level oblique aerial photography flight was made of the entire Illinois Lake Michigan shore. Also included was that part of the Wisconsin shore that is between Winthrop Harbor, Illinois, and Kenosha, Wisconsin. It has been well established that a major part of the littoral sediment stream that comes into Illinois is derived from that 6-mile reach of Wisconsin shore. More than 600 photos were taken. They show that despite relatively low lake levels there are many examples of severe shore erosion as well as a paucity of normal sandy beaches.

Coastal Erosion Studies

North Point Marina Bathymetric Monitoring, *Chrzastowski, Terpstra, Fucciolo, Riggs, Horstman, Jennings, and Miner* In July 1989 and June 1990, the ISGS field survey crew completed bathymetric data collection at North Point Marina. Staff then compiled maps covering nearly 1½ miles of shore. The mapping effort revealed serious shoaling problems south of the entrance to the new harbor resulting from erosion of the dredge-spoil fan delta. Also, scouring was evident north of the North Breakwater.

Comparing the 1989 and 1990 bathymetric maps of North Point allowed identification of nearshore areas of erosion and accretion. A copy of the map of lake-bottom changes has been supplied to the IDOT.

Log-Spiral Erosion Monitoring at North Point, *Chrzastowski, Terpstra, and Fucciolo* Rapid erosion identified just south of North Point Marina was threatening newly constructed parking facilities. This erosion at the dredge-spoil fan delta modified both the shoreline and a 1- to 4-meter scarp into a logarithmic-spiral form. Between January and October 1989, from the riprap terminus to 150 meters south, more than 60 meters of scarp recession occurred, with mean recession rates ranging from 2 meters per month near the riprap terminus to 17 meters per month near the south end of the monitoring area. During peak high-wave events scarp recession reached a rate of 40 centimeters per hour.

Modeling of an equilibrium logarithmic-spiral shoreline showed that eventual recession would cut through the parking lot and access roads. Projecting rates of recession suggested these facilities could be intercepted by the spring of 1990. In response to a nonsite emergency, a meeting was held August 15, 1989, where project managers and engineers agreed to construct a concrete cube revetment lakeward of the eastern most access road. Using monitoring information provided by the ISGS, erosion was allowed to continue to this line to remove lakefill that would otherwise require excavation. A revetment was constructed in November 1989. This case history documents rapid log-spiral bay development and the potential for rapid erosion of undefended gravelly sand lakefill on the Illinois shore.

Throughout the winter and spring, monitoring and photography continued along the marina shoreline. Reports were made to the Illinois Department of Conservation (IDOT) regularly. Rapid erosion was documented along the 160-meter segment of riprap protecting the north half of the fan delta. The stones were found to be shifting lakeward and downward, allowing erosion of fill behind them. Between 10 and 40 feet of recession was measured between February 14 and March 14—one-half acre lost in 28 days—indicating the need for remedial measures even though more than 150 meters of riprap revetment and more than 300 meters of concrete-block revetment were built in 1989 to stem the recession.

Two reports were presented at the 1990 North-Central Geological Society of America meeting held at Macomb, Illinois.

History of Illinois Shore Recession, *Jennings* The acquisition of historical maps is an important part of the effort to determine long-term erosion rates along the Lake Michigan shoreline. During August, records of government surveys along the Illinois/Indiana boundary were obtained. These surveys, primarily from the 1830s, are important because they constitute the earliest historical record in these areas. Nineteenth and early twentieth century subdivision plats were obtained from records maintained by Lake County. An atlas from the Illinois State Library included a series of detailed surveys made during 1895-1896 from the north side of Chicago to Waukegan Harbor. A series of detailed 1939 survey plats were located at IDOT. These findings are of particular importance when used in conjunction with aerial photographs from nearly the same time.

Building Deterioration and Proposed Rebuilding of the Chicago Lakefront, *Chrzastowski* A report concerned with the Chicago shoreline was completed in May for publication in *Shore and Beach*, the journal of the American Shore and Beach Preservation Association. It summarizes Chicago's lakefront history of construction and deterioration, the proposal for mitigation and new development of the Chicago Shoreline Protection Commission, and subsequent proposals by the U.S. Army Corps of Engineers and the Chicago Park District.

Chicago Lakefront Shore-Structure Survey, *Chrzastowski* During December, a field examination of the above-water condition of shore-defense structures was made along the entire Chicago lakefront. Above-water conditions were compared with underwater conditions recorded in 1988 by sidescan sonar. The study verified the revetment deterioration processes first proposed by ISGS in 1988.

Framework Studies (Bathymetry and Lake-Bottom Morphology)

Chicago Small Boat Harbor Maps, *Fucciolo, Terpstra, Horstman, Jennings, and Miner* During the fall and winter of 1989-1990, six of Chicago's small boat harbors were mapped: Belmont Harbor (1:2400), Diversey Harbor (1:2400), Fifty-Ninth Street Harbor (1:1200), Jackson Park Harbor (1:1200), Burnham Park Harbor (1:2400), and Montrose Harbor (1:1200) were completed.

Quality Control for Bathymetric and Base Maps, *Jennings, Terpstra, Matthews, Fucciolo, and Horstman* The original base maps from which most shore bathymetric and bottom maps have been developed are U.S. Geological Survey quadrangles and Illinois Department of Transportation (IDOT) aerial photos. Previous adjustment for distortion has mainly been accomplished by computer manipulation. Lists of survey monuments were obtained from IDOT, the Chicago Park District, and county and municipal agencies. Using theses lists and a program of Electronic Distance Meter Surveys, researchers are checking the positions of land features through quality land surveys and removing the distortion and errors from maps and photos. Coverage thus far includes all of the shore from Wisconsin to Waukegan, Lincoln Park as far south as North Avenue, and the entire Monroe/Chicago Harbor area.

Lake History Studies

Discovery of Early Holocene, Lake-Bottom Forest Remains, Shabica (Northeastern Illinois University), Chrzastowski (ISGS), and Folger (USGS) In June 1989, exposed stumps of a relict forest were found on the floor of Lake Michigan by Chicago-area diver and salvage operator, Alan Olson, and his associates. The site is 15 miles east-southeast of Chicago Harbor in 80 to 85 feet of water. In December the ISGS radiocarbon-dated samples from one stump and determined an age of 8,120 years. Stump samples subsequently dated by the ISGS in spring 1990 have given close agreement at about 8,300 years. At least 50 stumps occur at the site. The find offers unprecedented research opportunities for lake-level history, paleoclimate studies and lakeshore evolution. In the scientific literature, the site has now been named the "Olson Site" in recognition of the lead diver who made the find. The discovery and preliminary findings were reported in April at the meeting of the North-Central Section of the Geological Society of America in Macomb, Illinois.

In May a research cruise was conducted aboard the 67-foot vessel, *Neptune*, to map the lake-bottom characteristics at the site and gain information on the geologic history. This was a cooperative study by the ISGS, the U.S. Geological Survey (USGS) Branch of Atlantic Marine Geology, and Northeastern Illinois University. The data collection included sidescan sonar to produce a sonar mosaic of lake-bottom features, detailed bathymetric mapping, and seismic profiling. Preliminary data analysis suggests the stumps are the remains of a forest that grew within a broad gully of a stream that flowed to an ancestral Lake Michigan that was 90 or more feet lower than present lake level.

New ^{14}C Ages on Late Holocene Peat Accumulation in Beach-Ridge Swales at Illinois Beach State Park, *Hansel, Chrzastowski, Riggs, Miller, and Follmer* A study of 102 vibracores from ridges and swales in the beach-ridge complex at Illinois Beach State Park provided new information on late Holocene lake-level fluctuations. This locality, has undergone a complex depositional history. ^{14}C ages of basal peat and organic silt from swales do not provide close age control on the time of formation of the lakeward beach ridge as previously assumed. Instead, ^{14}C age estimates of peat and organic sediment from the base of swales cluster about two time intervals, one from about 2,500 to 2,200 years before the present (BP) and a second from about 1,600 to 1,000 BP. We interpret these to represent times when the water table rose to intersect the base of interridge swales and produced marshes and peat accumulation. This age control on water-table fluctuation in the complex may provide an indirect measure of the timing of water-level fluctuations in Lake Michigan.

In historic times the youngest and most-lakeward swales in the beach-ridge complex appear to have been dominated by eolian sedimentation. This leads workers to suspect that a considerable time lag may exist between the formation of a new beach ridge and the accumulation of organics in the adjacent swale. A report of these findings was made in May at the 1990 North-Central Geological Society of America meeting in Macomb, Illinois.

Ice Studies at Wilmette, *Miner* A revised report, "Lake Michigan Icefoot Complex: Conditions of Formation and Destruction—An Evaluation of Winter Shore Erosion at Wilmette, Illinois," underwent preliminary evaluation and editing in February for publication in the ISGS Environmental Geology Series.

Ice Erosion Dynamics at Wilmette, *Kempema (University of Washington, Oceanography), Chrzastowski (ISGS) and Haines (USGS)* From December 5-15, 1989, beach and nearshore profile data were collected at Wilmette. Fourteen profile lines extending from the beach across the icefoot to 3,000 feet offshore were made on a 15-meter spacing. This data collection is part of a study to evaluate lake-bottom erosion caused by the downward-directed wave energy along the lakeward face of the ice foot. The study is also addressing the volume of sand that can be removed from the beach and nearshore zone by ice dynamics.

Onshore-Offshore Sediment Transport at Wilmette, *Haines (USGS) and Chrzastowski* (ISGS) During April the nearshore area at Wilmette's Gillson Park was equipped with an array of floating and lake-bottom electronic instruments to measure the rates at which sand may be transported from the beach and shallow lake bottom to deeper offshore sites. The monitoring included sediment transport during several spring storms. This study concerns the potential loss of beach sand by such processes as rip currents and reflected waves.

Second Annual U.S. Geological Survey (USGS) Workshop on Southern Lake Michigan Coastal Erosion, *Chrzastowski and Hansel* USGS staff, Indiana Geological Survey staff, and ISGS staff met on February 6-7, 1990, at the USGS Center for Coastal Geology in St. Petersburg, Florida. Plans for cooperative cruises and other field efforts were developed. Brief reports on special research efforts were presented. Proceedings of the meeting were published in a workshop summary (USGS Open-File Report 90-272, May 1990) and a progress report (USGS Open-File Report 90-295, May 1990). Three ISGS short papers and four abstracts were included.

Testing of Nearshore Vibracoring Capabilities, *Chrzastowski (ISGS), Pranschke (Northeastern Illinois University), and Thompson (Indiana Geological Survey)* On October 10 and 11, 1989, a field test was performed from the 40-foot research vessel, *Chippewa*, to test the capacity of the equipment to vibracore nearshore sand bodies along the Chicago lakefront. A report was provided to the Illinois/Indiana Sea Grant Program.

Environmental Geochemistry

Field Evaluation of Membrane Bags as Biological Surrogates: Indiana Harbor and Canal Area, *Risatti* This project began in 1989 for the Army Corps of Engineers, Chicago Branch, in conjunction with the Indiana Harbor and Canal project. It was completed and the final report accepted in October 1989.

Technology Transfer and Information Services

Sidescan Sonar Examination of Navy Pier, Dime Pier, and Vicinity, *Chrzastowski* In a report on sidescan sonar examination of underwater structural conditions and lake-bottom conditions were provided to the major parties involved in a state-sponsored redevelopment project at Navy Pier and Dime Pier. The report and copies of 100 and 500 kiloHertz sonographs were sent to the Illinois Department of Conservation; Moffatt and Nichol Engineers of Long Beach, California; Johnson, Johnson and Roy Consultants of Ann Arbor, Michigan; and Stanley Consultants of Chicago.

Instruction in the Use of Sidscan Sonar in Coastal Monitoring, *Chrzastowski* Copies of field photography, ISGS reports, and selected sonograph records were provided to the Geology Department at Grand Valley State University in Michigan for classroom examples of sidescan sonar applications in coastal geology.

Lake Michigan Bibliography: Geological and Physical Processes Update, *Morgan and Holm* The *Lake Michigan Bibliography* was published in December as a document containing 477 cross-referenced citations for 1989 and earlier years. Also during the fall, a marketing study was made involving both telephone and mail surveys to determine whether or not a continuing bibliography effort could be made self-sustaining. The conclusion was that the bibliographies could not support themselves. Funding does not now permit continuation of compilation, although the ISGS continues to collect citations.

Coastal Studies Poster Presentation, *Terpstra and Chrzastowski* In October 1989, computer maps of Lake Michigan areas were completed in October for display as part of a larger ISGS exhibit, including maps of (1) the North Point Marina log-spiral bay development; (2) Chicago lakefront sediment accretion, showing historical shoreline accretion north of the Chicago River; (3) the North Avenue/Fullerton Beach, showing nearshore lake-bottom accretion; and (4) the North Point Marina vicinity bathymetry for the summer of 1989.

RIVERS, BACKWATER LAKES, AND WETLANDS RESEARCH

Riverine and wetlands research is expected to grow in the near future as a result of increasing concerns over water quality and the role of natural systems in buffering various manmade contaminants introduced into the environment. Long-Term Ecological Research (LTER) was completed at the end of the previous year with only minimal wrap-up tasks carrying over into this period. ISGS work for the past year centered on three major projects, including continuation of the Des Plaines wetlands demonstration project in Lake County, a sediment-accumulation study of the Grand Calumet River, and the initiation of a study to determine potential impact on a fen resulting from intrawatershed development in McHenry County.

Potential Impacts on the Hydrology and Ecology of a Pristine Fen Resulting from Intrawatershed Development, *Cartwright, Hensel, and Panno* The purpose of this research, funded from May 1990 to May 1991 by the Water Resources Center at the University of Illinois, is to identify and evaluate impacts of watershed development on the vegetation and hydrology of a pristine fen and associated wetland, and determine what, if any, options may be used to minimize the adverse effects of urbanization on the wetland complex. The fen is located in the city of Crystal Lake, McHenry County. The focus of this research is to (1) determine the source, direction, and volume of groundwater flow, (2) inventory and quantify the composition of plant communities of the fen and associated wetlands, (3) investigate the relationship between groundwater and the fen community, and (4) determine the susceptibility of the fen to change in groundwater quantity and quality induced by residential development within the watershed.

Geochemistry of Sediments, *Cahill* The Grand Calumet River has been impacted by a variety of industrial and navigational activities for many years. A reliable technique is needed to determine the rates of sediment accumulations in the area to aid in any environmental cleanup efforts that may be proposed. Cesium-137 dating was found to be a feasible method for determining sedimentation rates in the Grand Calumet River. Two core locations were chosen, each of which was suspected of receiving a high sediment load. The first location was found to have a very low sedimentation rate (0.3 centimeter per year) while the second location had a sedimentation rate in excess of 5 centimeters per year.

Wetlands Demonstration Project Along the Des Plaines River in Lake County, Illinois, *Miller, Hensel, and Berg* The ISGS is part of a multidisciplinary team investigating the impacts of four experimental wetland areas (EWA) at the Des Plaines River wetlands demonstration site. The purpose of an EWA is to purify river water, which is supplied through pumps. Groundwater levels have been monitored in 76 wells on a monthly basis since late 1987. A mathematical groundwater model has been used to estimate the groundwater flux for the EWA and the river. These wetlands are losing water to the subsurface (recharging groundwater), but the rate of loss is insignificant when compared to the capacity of the pump. Groundwater discharge to the Des Plaines River may have doubled since the EWA became operational. Monitoring of the hydrologic regime continues.

Tasks that have been accomplished to date include

- a survey of 28 established river cross sections in October 1989 and July 1990: The data, which were entered into computer databases, are being analyzed for changes in channel sediment storage. Floodplain erosion grids were measured, and the data will be compared with 1988-1989 data for indications of change in floodplain sediment storage.

- monitoring an established network of piezometers and groundwater observation wells on a monthly basis: Modeling has been provided to help Wetlands Inc. produce a water budget for each of four operating wetland areas. Seepage meters have been placed in selected wetland areas to help determine the hydraulic conductivity of underlying sediments.

A report by Bruce L. Rhoades (University of Illinois) and Michael V. Miller is being submitted to the journal, *Earth Surfaces Processes.* A final report was prepared under for the Illinois Department of Natural Resources and Energy; the contract ended in August 1989. Work is continuing for the period September 1989 through November 1990 under contract with Wetlands Inc. in Chicago.

HYDROGEOLOGIC INVESTIGATIONS

The ISGS has a mission to perform hydrogeologic investigations that support groundwater protection and resource programs. Major efforts are concentrated on projects implemented to meet the mandates of the Illinois Groundwater Protection Act (IGPA). Cooperative projects involving the Illinois State Water Survey (ISWS) and Illinois Department of Agriculture (IDOA) have focused on agricultural chemicals and groundwater quality. The ISGS has also been in the process of preparing for publication of the *Potential for Aquifer Recharge* map. In addition to IGPA studies, there have also been significant advances in the field study of transit time through compacted clays, and in environmental isotope studies that indicate the extent of recharge in the Mahomet aquifer.

Studies related to hydrologic processes give us insights into how and when we should protect groundwater resources. Future work on groundwater protection will focus on methodological development for county and municipal hydrogeological mapping, continuous enhancement of studies in agricultural chemicals in groundwater, and further cooperation with state and federal agencies interested in joint groundwater protection studies.

Groundwater Protection

Environmental Effects of Oil Field Brines, *Hensel, McKenna, and others* The Illinois Department of Energy and Natural Resources (ENR) funded a reconnaissance study to assess the effects of past and present oil-brine disposal practices on the water, soil, and biotic resources of southeastern Clay County. This project has been completed and is an open file report. Findings from this research have shown that localized areas of groundwater contamination exist around filled-in abandoned brine pits. However, no degradation of groundwater quality in the regional sandstone aquifer could be attributed to brine disposal.

Literature Analysis on the Effects of Municipal Landfills on Groundwater Quality, *Roy* Because of public opposition, it has become very difficult to site new municipal landfills. Concerns about groundwater contamination have been an issue for decades. This concern was the impetus for a comprehensive analysis of the scientific literature that will summarize past experiences with municipal landfills, and future expectations. The chemical composition of landfill leachate and gas has been quite variable and difficult to predict. Pathogens are not a major concern, but about half of the volatile organic compounds (VOCs) in leachate are highly or very highly mobile in groundwater. Some of these compounds can readily volatilize from leachate in the unsaturated zone and chemical oxidation and hydrolysis of VOCs in landfill leachate may not be significant. Many organic compounds may biodegrade, but a few appear to be resistant.

Few case histories were found where municipal landfills resulted in serious groundwater contamination, but the majority of active landfills did not have any type of groundwater monitoring program. Most problem landfills were located in geologically unsuitable areas, constructed without an effective liner, or were poorly operated. Proposed regulations may mandate the use of soil liners, leachate collection systems, final covers, and other requirements, but there was very little documentation to evaluate the efficacy of these requirements. Future municipal solid waste landfills should be protective of human health and the environment if sited, constructed, and operated correctly. Short-term remedies to the landfill crisis include onsite expansions and landfill mining. Based on case studies, and the potential efficacy of Federal guidelines applied in Illinois, the public's concern for groundwater contamination by future municipal landfills may be unjustified.

A report is in preparation to be included as a chapter in the book, *Advances in Environmental Science.*

Pilot Study—Agricultural Chemicals in Rural Private Water Wells, *Dreher, J. Chou, Valkenburg, McKenna, E. Mehnert, Dey, and Greenpool* The Illinois State Geological Survey (ISGS) and the Illinois State Water Survey (ISWS) are beginning a pilot study, planned last year in cooperation with the Illinois Department of Agriculture (IDOA), to field test and evaluate various components of the experimental design proposed in the recently completed ISGS/ISWS Cooperative Groundwater Report 11, *Agricultural Chemicals in Rural Private Wells in Illinois: Recommendations for the Design of a Statewide Survey.* The pilot study will provide a preliminary assessment of the occurrence of agricultural chemicals in rural private wells in five representative hydrogeologic settings in the state. USEPA National Pesticide Survey (NPS) methods 2 and 3 are being followed in the ISGS portion of this study with minor modifications. As samples are analyzed, the data are entered into a database developed for this purpose by the Illinois State Water Survey (ISWS).

This project is jointly funded by the Illinois Environmental Protection Agency (IEPA) and the Illinois Department of Energy and Natural Resources (ENR).

Impact of Agricultural Chemicals on Groundwater Quality, *Groundwater Protection Section staff* and Bicki (University of Illinois, Agronomy) In February 1990, ISGS/ISWS Cooperative Groundwater Report 12 was released to the Illinois legislature. The report presents an initial evaluation of the potential impact

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(A) Michael Summers and Daniel Kelleher, Environmental Studies and Assessment, retrieve soil gas probe for determining possible contamination on project right of ways for the Illinois Department of Transportation. (B) Coal company representative, Survey geologist, and University of Illinois agronomist collaborate on a project for the Illinois Mine Subsidence Research Program. (C) Mary Greenpool and William Dey, Groundwater Protection, sample a farmer's well for pesticides. (D) The *Neptune*, leased by the USGS and ISGS, is used by scientists in Lake Michigan Coastal and Basin Studies. (E) Brandon Curry, Quaternary Framework Studies, cleans an exposure of glacial till at the Martinsville Alternative Site, proposed for a low-level radioactive waste disposal facility.

of agricultural practices on groundwater quality, makes recommendations to minimize impacts, and summarizes previous studies to assess pesticide impacts on groundwater quality in Illinois. Changes in current practices in pesticide selection and application rate, nitrogen fertilizer application rate, and crop rotations have the greatest potential for minimizing the effects of agriculture on groundwater quality. Data are insufficient to accurately determine what impact pesticides have had on groundwater quality in Illinois. Sampling in Illinois and other midwestern states shows, however, that shallow aquifers are vulnerable to contamination.

Statewide Survey for Agricultural Chemicals in Rural, Private Water Supply Wells, *McKenna and Mehnert* The ISGS is cooperating with the Illinois Department of Agriculture (IDOA) and the University of Illinois Cooperative Extension Service in a survey to begin in October 1990. A sampling of more than 400 randomly selected wells will provide the first statistically valid statewide estimate of the occurrence of agricultural chemicals in rural private wells. However, the study will not determine whether any areas of the state are more vulnerable to contamination than other areas. During FY90, funding to the ISGS in support of these activities was supplied through the Hazardous Waste Research Fund (Groundwater Protection Act) and ENR.

Geologic Framework for Determining Underground Sources of Drinking Water, *Poole, Vaiden, Graese, Chenoweth, Orozco, Cantwell, Shaw, and C. Treworgy* This third phase of the project began in August 1989 with support from the Illinois Department of Mines and Minerals. Water is considered unfit for human consumption if the total dissolved solids content is greater than 10,000 parts per million. According to law, oil and gas wells must be cased through potential drinking water supplies.

East-west and north-south cross sections illustrating the relationship between stratigraphy and estimated water quality are being prepared for 19 oil-producing counties. These include Bond, Clark, Clinton, Cumberland, Edwards, Effingham, Fayette, Franklin, Gallatin, Hamilton, Jasper, Jefferson, Marion, Richland, Saline, Washington, Wayne, White and Williamson. Cross sections and reports for Cumberland, Edwards, Franklin, Hamilton, Jasper, and White Counties have been completed and submitted to the funding agency. Cross sections and reports for Clark, Gallatin, Jefferson and Richland Counties have been reviewed and await final production. The project is scheduled to be completed in FY91.

Evaluation of Yard Waste Composting with Regard to Pesticides and Other Toxic Residues, *Kovacic (University of Illinois, Landscape Architecture) and Bicki (University of Illinois, Agronomy); and Cahill (ISGS)* The Center for Solid Waste Management and Research at the University of Illinois funded this study to identify the potential leachates which may form during the composting of yard wastes. The mobility of the degradation byproducts of the various chemicals applied to yard wastes into groundwater or onto crops used for human consumption will be controlled, in part, by differences in soil compositions. A conclusion of the study was that residues should be monitored at a controlled location and that environmental site monitoring data currently are lacking for most chemicals expected to be generated from composted yard wastes.

Potential for Aquifer Recharge in Illinois (Map), *Keefer and Berg* The map, *Potential for Aquifer Recharge*, was generated for the Illinois Groundwater Protection Act. A reduced-scale copy of the map was made, and approximately 100 color-photocopies were distributed to members of the General Assembly, Illinois Department of Energy and Natural Resources, and Illinois Environmental Protection Agency. Digital files of the full-size map were finalized and sent to an outside firm for the generation of negatives to be used in printing. ISGS staff are currently assisting in the interpretation of the digital files and generation of the negatives. Bids were received for the publication of the full-size map upon receipt of the negatives.

Drainage Tile Monitoring Study, *Keefer* Water samples continue to be collected from drainage tiles, soil-water samplers, and groundwater monitoring wells to be analyzed for several pesticides. The study, supported by the Water Resources Center of the University of Illinois, will report the detected occurrence of the selected pesticides in these samples and attempt to evaluate the relationship between concentrations of drainage tile effluent and shallow groundwater. Sampling for this project will be completed in August 1990.

Pesticide Management Plan, *McKenna* The ISGS is providing technical assistance to the Illinois Department of Agriculture (IDOA) in developing a strategy for managing pesticide use to prevent groundwater contamination. The plan, mandated by the U.S. Environmental Protection Agency (USEPA), emphasizes groundwater monitoring and differential protection of groundwater based on vulnerability to contamination.

Methodology for the Regional Assessment of Aquifer Contamination Potential Based on Geologic Framework, *Soller (USGS, Reston) and Berg (ISGS)* It has become a national priority to identify and evaluate groundwater resources that may potentially become contaminated. The ISGS is cooperating with the U.S. Geological Survey (USGS) to develop a methodology which will help assess contamination potential of aquifers on a multistate basis. Information is derived from three-dimensional texturally based geologic maps recently produced by the USGS. The texture of surface sediments, permeability of the bedrock directly beneath surficial deposits, presence of aquifers, and thickness of surficial deposits are the four parameters evaluated in this investigation. A scheme was devised to compare hydrogeologic settings according to relative degrees of susceptibility to contamination. Results of the investigation will be submitted to an appropriate journal for publication in the fall of 1990. This work was supported by USEPA Region V.

Contamination Potential Map of the Chicago 3°x 6° Sheet, *Soller (USGS, Reston) and Berg (ISGS)* A contamination potential map of the Chicago 3°x 6° sheet, including parts of Illinois, Indiana, Ohio, Michigan, and Wisconsin, is being produced in a cooperative effort by the USGS and the ISGS. Geologic information is derived from USGS source maps. Methodological development for determination of the contamination potential ranking scheme of hydrogeologic settings was contributed mainly by the ISGS. This map will be published by the USGS, after undergoing internal and external review during the latter part of 1990. The investigation was supported by USEPA Region V efforts to better understand contamination potential problems caused by agricultural chemicals on a regional basis.

Groundwater Protection Programs of the Illinois State Geological Survey and the Illinois State Water Survey, *Berg and McKenna (ISGS); Wehrmann and Shafer (ISWS)* A briefing paper will report on the status of groundwater protection programs that have been conducted throughout the state and plans for the future. Included in this paper will be specific examples of geologic mapping, water quality assessments, water quantity assessments, and technical assistance programs that have been undertaken in the state. The paper highlights the need for a unified, systematic, large-scaled mapping and assessment of groundwater resources. Most studies done in the state have been regional investigations or specific to a need. It is anticipated that this paper will completed by the end of 1990.

Preliminary Assessment of Leaking Underground Storage Tanks—Illinois Environmental Protection Agency (IEPA) Regions 1 and 2, *L. Smith, Denhart, Keefer, and Abert* Two regional studies included the Geographic Information System (GIS) automation of location data for 546 underground petroleum product storage tanks located within the IEPA Regions 1 and 2—a 21-county area in northern Illinois. These projects were funded though Camp, Dresser, McKee (CDM), Inc., Chicago, for the IEPA. A model of the vulnerability of shallow and deep aquifers to contamination from surface and near-surface sources of waste, developed by ISGS staff, was used to rank the relative contamination potential of the 546 tank locations. These ranks and the proximity of the tanks to known private, public, and industrial wells were weighted and put into a prioritization model by CDM to determine which sites IEPA should investigate first for remediation. Both studies have been completed and the final report accepted.

Numerical Estimates of Potential for Groundwater Contamination from Land Burial of Municipal Wastes in Illinois, *Hensel, Berg, and Griffin* This research quantitatively ranked several mapped hydrogeologic scenarios common to Illinois for the potential for groundwater contamination due to land burial of municipal wastes. Also, an evaluation was undertaken to determine whether a proposal by the Illinois Pollution Control Board (IPCB) for a groundwater compliance distance of 100 feet is appropriate as a regulatory criteria of maximum leachate migration from municipal landfills. This project was completed; the final report is in press. Results show that it is possible to numerically rank potential for contamination, and that the proposed 100-foot compliance distance may be appropriate. The project was sponsored by the Hazardous Waste Research and Information Center and the IPCB.

Hydrogeologic Processes

Field Study of Transit Time Through Compacted Clays, *Cartwright, Krapac, Herzog, Panno, Hensel, and Rayfield* This study is funded by both the U.S. Environmental Protection Agency (USEPA) and the Hazardous Waste Research and Information Center (HWRIC). The study began in 1985 and should continue until at least 1991.

The experiment consists of a 8x15x0.9-meter clay liner ponded with 30 centimeters of water on the top. The liner performance is monitored with a total of 218 instruments in and on the liner. Data show that the hydraulic conductivity is significantly lower than the EPA maximum. The wetting front has penetrated to between 40 and 50 centimeters since ponding in April 1988; breakthrough of the tracers is now estimated to be between 4 and 6 years.

The paper, "Infiltration Measurements of a Field-Scale Soil Liner: Preliminary Results," was completed and submitted to the *Journal of Groundwater*. The manuscript describes the results of 2 years of infiltration measurements and related experiments conducted at the liner. The data show that the liner successfully achieved USEPA criterion for a low saturated hydraulic conductivity, that hydraulic properties of the liner are homogeneously distributed, and that water probably will not come through the bottom of the liner until April 1992.

A second paper, "Fluctuations in the Measurement of Water Infiltration into a Field-Scale Soil Liner," describes the effects of construction, changes in pond level, and barometric pressure on the infiltration of water into the liner. Barometric pressure appears to exert a strong influence on infiltration into the liner—that is, as barometric pressure increases, infiltration decreases. Laboratory experiments are being prepared to explore this relationship further, and these data will be incorporated into the manuscript.

Mobility of Incinerator-Ash Leachate in Compacted-Soil Liners, *Roy, Krapac, and Steele* The ISGS continued to study the efficacy of soil liners in protecting groundwater from ash leachate. The migration of some metals through liners into groundwater may be accelerated by chloride complexation; ash leachate typically contains high concentrations of chloride that reacts with dissolved metals. Preliminary results have demonstrated that the adsorption of lead and cadmium by illite and kaolinite decreases with an increase in chloride concentration, and therefore they would be more mobile in the environment. However, comparisons with metal-nitrate systems suggest that this reduction in adsorption was more the result of competitive interactions with sodium; complexation may have only a minor effect. Above a pH of 11, cadmium precipitated as cadmium carbonate. Future experiments will include mixing laboratory extractions of ash samples with clays commonly used to construct landfill liners. This project was funded by the USEPA.

Cave Studies, *Panno* Field trips are being set up to sample limestone adjacent to caves around the margins of the Illinois Basin. Caves that have already been sampled include the Mark Twain cave in eastern Missouri and Sensemeyer cave and Cave-in-Rock in southern Illinois. Sampling began during the latter part of June 1990. The samples are being sent to Lawrence Livermore Laboratory in California where the fluid inclusions within the calcite will be analyzed for changes in salinity (possibly a fingerprint of groundwater mixing). This work is a follow up to the development of a hypothesis that links Pleistocene glaciation and cave formation along the margins of the Illinois Basin and other basins in the eastern midcontinent region of the United States.

Environmental Isotope Studies, *Panno, Cartwright, Coleman, and Liu* A literature review has been completed on the use of environmental isotopes in the investigation of pore water and groundwater in glacial tills. The evaluation of infiltration water in glacial till and underlying aquifers in the counties of Iroquois, Champaign, Piatt, McLean, and Tazewell is planned. Groundwater samples will be collected from the Mahomet Valley Bedrock Aquifer along its path across east-central Illinois, and from shallower aquifers in the Glasford Formation. Pore water will be collected from overlying tills. This preliminary work should yield an indication of the extent of recharge that takes place through the glacial till and into the Mahomet Valley Bedrock Aquifer. Currently, wells have been selected and sampling will begin in September 1990.

WASTE MANAGEMENT

The ISGS has long had a waste management research program. Recently, this program has concentrated in four primary areas: technical assistance to counties on solid waste issues, characterization of low-level radioactive waste sites, deep-well injection of waste, and coal waste. Low-level radioactive waste characterization is an outgrowth of a long-standing ISGS program to evaluate the completeness and scientific accuracy of waste disposal siting and geologic characterization. Research into deep-well injection and coal wastes evaluates the movement of contaminants in groundwater and the capability to predict and trace contaminant migration.

The ISGS responds to issues regarding the relationship between waste disposal/management and geology/hydrogeology. Responses are limited to areas of expertise. Through communication with and cooperation from private consultants, waste disposal facility developers, and other state agencies, the ISGS works to ensure a solid understanding of the geology of existing or potential waste sites and the pathways for fluid movement. It seeks to provide scientific information useful in problem resolution and decision making.

Solid Wastes

County Assistance Project, *McKay, Krumm, McLean, Riggs, and Abert* This program began in 1990 to provide geologic mapping and screening, using the computerized Geographic Information System (GIS), to counties where solid waste siting is of immediate concern. The Office of Solid Waste and Renewable Resources, Illinois Department of Energy and Natural Resources (ENR), is funding this project to offer technical assistance to county and local governments in the GIS screening of their areas for potential solid waste disposal sites. This detailed mapping effort is designed to compliment an initial countywide GIS screening being performed by the ENR Office of Research and Planning. ISGS staff have met with officials from Whiteside, Madison, Lake, and Sangamon Counties to discuss landfill and other solid waste facility siting.

Champaign County—Geologic Assistance for Landfill Site Screening, *McKay, Smith, Pool, Krumm, Denhart, Killey, Trask, Abert, Graettinger, Taylor, Ploetz, Junkins, and Helm* The ISGS continues to assist Champaign County with screening for landfill siting. In a final presentation to the Champaign County Intergovernmental Solid Waste Disposal Association (ISWDA) on February 21, 1990, Dr. McKay presented maps that showed the results of the geologic mapping project, and identified the distribution and thickness of the major aquifers in the county and areas generally suitable for further evaluation for landfill siting. Forty-two maps of various criteria for landfill site screening were delivered to the county as a result of the 12-month project. The principal geologic products were maps of sand and gravel aquifer thickness in each of the Wedron, Glasford and Banner Formations, plus maps of drift thickness, bedrock topography, shallow geologic materials, slope, terrain, surficial sand and gravel deposits, gravel pits, surface water bodies, and private, public, and industrial well locations. Many of these products were derived from new digital "slice" maps, created with the assistance of the GIS and showing the stratigraphy and lithology of Quaternary deposits to a depth of 400 feet in the county.

The ISGS has reviewed the report on the site identification study issued by the Champaign County ISWDA. The report is based in large part on geologic and other mapping prepared by the ISGS and the Office of Research and Planning working with the OSWRR. The report identifies five areas targeted as potential landfill sites. One site will be selected in late 1990 as the top site, and land acquisition and drilling for verification will begin.

Champaign County—Field Trip for Landfill Siting Board, *McKay, Trask, Killey, and Kempton* The ISGS Computer Research and Environmental Studies Sections conducted a field trip in Champaign County for 25 representatives of the local Intergovernmental Solid Waste Disposal Association (ISWDA) and their Board Advisory Committee. Participants traveled through the west-central part of the county and examined glacial landscapes, till outcrops, gravel pits, and municipal water wells. The trip ended in the Natural Resources Annex Samples Library where participants examined cores of geologic materials. Throughout the trip, presentations and discussions were focused on the capability of geologic materials and settings for the siting of a municipal landfill. The trip was well received by local officials, who indicated that it was helpful to them in making decisions about landfill siting.

Lake County—Geologic Mapping for Solid Waste Facilities Siting, *Abert, Riggs, McLean, Krumm, McKay, Denhart, Junkins, and Helm* As part of the county assistance project, Lake County was selected for detailed geologic mapping. Lake County has an immediate need to identify sites for two sanitary landfills (one for general refuse and one for construction wastes) and six composting facilities. The main objectives for this work include (1) working with Lake County staff to select a study area, (2) establishing an agreement to exchange digital databases, (3) compiling a detailed geologic database of well data from information on file at the ISGS, (4) developing geologic maps showing the factors important to solid waste siting, and (5) producing capability maps. The geologic maps being prepared for Lake County will show the distribution and character of the glacial materials.

Champaign and Lake County Well Databases, *Denhart, Helm, Junkins, Abert, McLean, Riggs, and McKay* Paper records for more than 12,000 well locations in Champaign and Lake Counties were located and automated into two database systems: CONQuEST and Arc/Info (use of company product name implies no ISGS endorsement). The database includes header, completion information, lithologic descriptions, and stratigraphic information for about 900 wells as interpreted by ISGS geologists. This tabular database served as the basis of the work in the Geographic Information System, which was needed to assist the counties in their landfill siting efforts.

Use of Isotopic Analysis for Identification of Landfill Gas in the Subsurface, *Coleman, Liu, and Riley* The microbial decomposition of organic materials in landfills produces large quantities of methane. This gas has been identified as a significant contributor to the greenhouse effect; it can also migrate offsite and result in hazardous situations. Methane is the primary component of natural gas, coal gas, and marsh gas; therefore, it is sometimes necessary to distinguish landfill gas from gases produced by these other sources. Because the chemical composition of a gas can change as it migrates through the subsurface, chemical analysis alone does not always provide a method of identifying gas that originated in a landfill. A study was therefore carried out to determine if stable-isotope analysis (both carbon and hydrogen isotopes) and radiocarbon analysis could be used to effectively identify landfill gas and distinguish it from gases from other sources.

The results of this study were presented at the Governmental Refuse Collection and Disposal Association's 13th Annual International Landfill Gas Symposium. In most cases, landfill gas can be identified with a combination of chemical and stable isotope analyses. Carbon-14 analysis is the most definitive method for identifying landfill gas, but it requires large samples (several liters of gas) and is more costly than the other analyses. Carbon-14 is therefore recommended primarily for verification.

Hazardous Wastes

Deep Well Disposal of Industrial Wastes, *Cartwright* Testimony was provided to the Illinois Pollution Control Board (IPCB) on May 17 and June 5, 1990, on the deep-well injection of industrial wastes (UIC program). The Illinois State Geological and State Water Surveys were mandated by the General Assembly to study and report on the state's UIC program. The Hazardous Waste Research and Information Center (HWRIC) funded the study. The draft report was circulated nationally to scientists, industries, and regulatory agencies for review. The final report, *Evaluation of Underground Injection of Industrial Waste in Illinois*, Illinois Scientific Surveys Joint Report 2, was released in 1989 and served as the written testimony of the Illinois Department of Energy and Natural Resources to the PCB.

Underground Injection Control Class I Service Program, *E. Smith, E. Mehnert, and Cantwell* The ISGS continues to provide technical expertise and advice to the Illinois Environmental Protection Agency (IEPA) and U.S. Environmental Protection Agency (USEPA), Region V, in the Class I Underground Injection Control Program. Activities include review of permit applications, permit modifications, monthly operating reports, and other related technical documents pertaining to the hazardous waste injection wells and review of the local and regional geology and hydrogeology of these sites. A computerized database to facilitate the review process continues to be developed and updated. A manual for the database was revised to facilitate training and operation of the database. IEPA staff have received training in the use of the database. Three separate petitions and related documents for the continued injection of hazardous wastes and the results of four mechanical integrity tests of injunction wells were reviewed during 1990. Technical assistance and review was provided during the plugging and abandonment of an injection well at Marshall, Illinois.

Plausible Geochemical Reaction Products from Two Deep-Well-Injected Hazardous Wastes *Roy, Seyler, Steele, Moore, and Krapac* In underground injection—a waste management technique used in Illinois—liquid wastes are placed into geological formations. Geochemical reactions between the wastes and receiving formation may determine whether injection at a specific site can be viewed as a waste storage technique, or a waste treatment approach where the liquid is transformed into a nonhazardous waste. Predicting these chemical reactions is important to ensure that injection is protective of the environment. In this laboratory study, samples of two waste streams (a highly alkaline, brine-like solution, and a dilute hydrochloric solution) were collected at injection facilities in Illinois and mixed with ground core samples of injection formations for 155 to 230 days at 52°C at 10.8 MPa pressure. The acidic waste was neutralized by carbonate dissolution, whereas the major-element composition of the alkaline waste was not altered. Mixing the alkaline waste with sandstone, dolomite, and siltstone yielded several reaction products. A computer-assisted thermodynamic model accurately predicted the presence of some of these reaction products, but there is a need to expand the database that is used in these kinds of predictive calculations. This project was funded by the Hazardous Waste Research and Information Center.

Evaluation of Underground Injection of Industrial Waste in Illinois, *Brower, Krapac, Hensel, and Illinois State Water Survey staff* The report of this study, mandated by the Environmental Protection Act in January 1985, was released in August 1989 as Illinois Scientific Surveys Joint Report 2. It reviews the regulations, permitting practices, disposal operations, fate of injected wastes, and disposal alternatives associated with disposal in Class I disposal wells in Illinois. A letter from the executive director of the National Water Well Association congratulated the authors on the quality of this report.

Low-Level Radioactive Wastes

Continued Technical Support to Battelle Relative to the Low-Level Radioactive-Waste (LLRW) Site Characterization, *Berg, Curry, M. Cartwright, K. Cartwright, Griffin, Curry, and Weibel* The state is actively working to locate a LLRW disposal site. During this period testimony was provided to the Senate Executive Committee investigating the site process. ISGS scientists have attended numerous technical meetings to interpret data for Battelle and their contractors working on site characterization. The ISGS has reviewed information from siting contractors at the candidate sites at Martinsville in Clark County and Geff in Wayne County. Chapters on stratigraphy, hydrology, geochemistry, seismicity, mineral and hydrocarbon resources, and groundwater modeling have all been both informally and formally reviewed under Battelle Quality Assurance procedures by ISGS staff. These chapters will become volumes 2 and 3 of the site characterization document. Volume 2, on stratigraphy and geotechnical aspects has also been reviewed. The ISGS geological report to Battelle on the glacial geology of the Martinsville site was completed and submitted to Battelle. This followed collection and analysis of thousands of samples for determination of particle-size and clay mineralogy. Because activities at the Geff site were suspended as of May 1, 1990, the ISGS report on the geology of the Geff site was not completed nor submitted. An ISGS publication on the geology of the Geff site is planned.

Three-Dimensional Modeling of the Martinsville Low-Level Radioactive-Waste Site, *Pool, Smith, and McKay* In conjunction with its efforts to characterize the Martinsville low-level radioactive-waste site, the Battelle Memorial Institute contracted with the ISGS to use the ISM/IVM software on the Silicon Graphics workstation (Build Illinois purchase) to produce a three-dimensional model of the subsurface geology of the Martinsville Alternative Site. The ISGS is working with Hanson Engineers and Battelle. The workstation will be used to demonstrate the model during siting hearings.

Carbon-14 Dating of Groundwater at Potential Storage Sites for Low-Level Radioactive Waste *Hackley, Liu, Riley, Cao, and Coleman* As part of the continued study for storage sites for low-level radioactive waste, the ISGS Isotope Geochemistry Laboratory was designated as the primary laboratory for radiocarbon (^{14}C) dating of groundwater at two potential low-level radioactive waste repository sites (Martinsville and Geff). Ages up to 45,000 years can be determined for groundwater by measuring the concentration of ^{14}C in the inorganic fraction of carbon contained in the water. Since the carbon in groundwater can originate from more than one source, the raw age must be corrected for the influx of carbon from the various potential sources.

The aquifers under study at Martinsville are in glacial deposits. Biodegradation of organic materials in glacial till causes formation of carbon dioxide and methanogenic bacteria, then conversion of part of this CO_2 to methane. These bacteria preferentially utilize ^{12}C in forming methane and thus the CO_2 remaining in the reservoir becomes enriched in ^{13}C. This ^{13}C enriched CO_2 can equilibrate with the bicarbonate in groundwater and increase the $\delta^{13}C$ value of the bicarbonate. Thus, in addition to pH and alkalinity analyses, the effect of methane formation on the $\delta^{13}C$ value of the dissolved inorganic carbon has to be determined before a correction can be applied to the raw radiocarbon date.

As this was the first groundwater-dating project involving the ISGS Isotope Geochemistry Laboratory, many new procedures had to be developed and tested. During the reporting period, a total of 41 ^{14}C dates (35 groundwater samples, 4 methane samples, and 1 soil-gas sample) from the Martinsville and Geff sites were reported to the funding agency, Battelle. Four gas samples extracted from groundwater at Martinsville were also analyzed for their chemical and isotopic compositions. The raw ^{14}C dates are currently being corrected for the influences of the dissolution of limestone and the decay of buried organic matter, and a report is being prepared for publication. Preliminary results indicate that by analyzing both the water and the dissolved gases, it is possible to apply a meaningful correction factor for the influx of CO_2 from the decay of buried organic matter. This discovery greatly expands the usefulness of radiocarbon dating of groundwater in glacial deposits.

Coal Wastes

Factors Affecting Management of Fine-Coal Cleaning Waste Solids, *Dreher, Chen, Rapp, Rostam-Abadi, Roy, Steele, J. Frost, R. Frost, and Henderson (ISGS); Berger (University of Illinois); and others (Southern Illinois University)* The environmentally acceptable disposal of three fine-coal cleaning wastes was studied. A column leaching experiment to test the feasibility of microbially assisted recovery of valuable metals from one waste solid sample was completed. The test showed that the method is chemically feasible and bears further research toward optimization.

Samples of fine-coal cleaning waste mixed with varying proportions of hydrated lime were combusted in a tube furnace attached to a quadrupole gas analyzer. Results of these combustion studies complement the fluidized-bed combustion (FBC) test conducted earlier and show that SO_2—evolved from the coal waste upon combustion—was efficiently captured when the Ca/S mole ratio was 1 or greater.

Aqueous batch extractions of the waste solids from the FBC test produced leachates that were highly alkaline—pH about 12. Leachates from FBC waste have much lower heavy metal concentrations than the acidic leachates from uncombusted wastes.

Recovery of Coal from Tailings Ponds and Effluent Streams of Operating Mines, *Khan, Baxter, and Rice* Coal-laden effluent rejected during the operation of present coal-cleaning plants was the topic of two papers presented at the 1988 National Symposium on Mining, Hydrology, Sedimentology, and Reclamation held in Reno, Nevada, December 5-9, 1988, and published May 1990. One paper suggests a flow diagram for secondary recovery that includes a desliming step (hydrocyclone) and subsequent physical cleaning steps (hydrocyclones, shaking tables, or spirals). The second explores the effect of rotor speed, aeration intensity, and the concentration of reagents on flotation behavior.

EARTH HAZARDS AND GEOTECHNICAL STUDIES

Many natural and cultural hazards present potential risks to human activities and structures throughout the state. Studying, documenting, and understanding the mechanism of each hazard or set of hazardous conditions contributes to accurate risk assessment. In addition, studies conducted on material properties of soil and rock aid in understanding the mechanisms, help prediction of impacts, and contribute to a database used for siting residential, industrial and public construction projects.

Radon

Radon and Naturally Occurring Radioactivity, *Cahill* In this ongoing research and service program, the following activities occurred during the reporting period: Radon measurements were made in samples of both natural gas and indoor air. Inquiries from the press, the general public, consultants, and other government agencies were answered. Information was provided to gas companies concerning the occurrence of radon in natural gas. Seminars on radon in Illinois were presented to the Department of Geography at the University of Illinois and to the City of Champaign Environmental Advisory Committee. In the Radon Proficiency Program established by the U.S. Environmental Protection Agency (USEPA), the laboratory passed Round 6 for radon measurements using charcoal canisters. A database of 16,331 indoor radon measurements made in Illinois was compiled from data provided by private companies and the Illinois Department of Nuclear Safety. The purchase of a an alpha spectrometer system, approved as part of the Build Illinois program, was delivered and is awaiting final setup. Inquiries on radiation in groundwater, and in particular, radium in northern Illinois were answered. Mr. Cahill was named as the ISGS representative to the AASG District 3 committee to review the joint USEPA/USGS Radon Potential Mapping Project.

Landslides

The proposal, "Landslides in New Madrid Seismic Zone: Landslide Inventory and Risk Assessment in Illinois Along the Ohio and Mississippi Rivers, from Paducah, Kentucky, to East St. Louis, Illinois," by **W. J. Su** has been recommended for funding by the U.S. Geological Survey (USGS). The project will begin in the fall.

Earthquakes

Seismicity of Illinois, *Heigold and Larson* The historical record of earthquakes with epicenters in Illinois has been examined. The cumulative amount of energy released during Illinois earthquakes is relatively small, far less than the energy released during the catastrophic earthquakes of 1811 and 1812 in the New Madrid Seismic Zone immediately south of Illinois. On the basis of the historical records and known zones of weakness in the earth's crust, it is concluded that the greatest seismic risk in Illinois is from large earthquakes that may originate in the New Madrid Seismic Zone.

Governor's Task Force on Earthquake Preparedness, *Heigold, DuMontelle, and Leighton* In the wake of the earthquake at Loma Prieta, California, on October 17, 1989, the Governor of Illinois formed a task force on earthquake preparedness. The ISGS made significant contributions to the subcommittee on seismic risk, testified at a public hearing of the subcommittee, and contributed issues and recommendations to the final report and reviewed the final document.

Illinois Mine Subsidence Research Program

The Illinois Mine Subsidence Research Program continues to support research to develop guidelines for underground mining methods that would maximize coal extraction while preserving the productivity of prime farmland in Illinois. The program is also addressing the needs of the mining industry for calculation of stable mine conditions for room-and-pillar mines and for predictions of subsidence. Participants with ISGS include the U.S. Bureau of Mines, the Department of Agronomy at the University of Illinois, the Department of Mining Engineering at Southern Illinois University, the Illinois Department of Mines and Minerals, and the Department of Geology at Northern Illinois University. The Illinois Coal Development Board and the U.S. Bureau of Mines continue to fund the program.

Illinois Mine Subsidence Research Program (IMSRP), *DuMontelle, Bauer, Trent, Brutcher, B. Mehnert, J. Kelleher, and Van Roosendaal* Activities from July 1988 through June 1989 were documented in a program assessment report approved by the Illinois Coal Development Board (ICDB) in November. Proposals for 1990-1991 were reviewed by the technical committee during the fall 1989. A program implementation plan for 1990-1991 was approved by the ICDB at their March meeting. Projects included in the plan were finalized, and contracts were implemented through the University of Illinois.

The IMSRP was given an Environmental Achievement Award by the National Environmental Awards Council. The program will be listed in the 1990 Environmental Success Index, which is a clearinghouse of information about groups working on solutions to environmental problems.

ISGS researchers are monitoring surface subsidence, overburden deformation, and groundwater conditions at two active longwall operations in southern Illinois. At a deep longwall mine in Jefferson

County, precision surveys and geotechnical instruments provided valuable information about surface movements, overburden fracturing, and changes in groundwater levels caused by subsidence. A similar monitoring program is still underway at another longwall site in Saline County.

As part of IMSRP research into longwall subsidence, Colin Booth, hydrologist from Northern Illinois University, is investigating the piezometric response to subsidence in the drift and bedrock. Both sites showed similar responses for water pressures in argillaceous sandstone aquifers. Water levels (pressures) dropped as mining approached and undermined the well; then water levels recovered within 3 months. Wells in the glacial material at one site showed no changes during mining. Robert Darmody of the Agronomy Department, University of Illinois, is continuing work on the effects of subsidence on agricultural soils and the impact of current subsidence mitigation practices on crop yields. Preliminary results show better yields on the mitigated land.

Paul Chugh of Southern Illinois University directed ongoing projects on surface subsidence monitoring, surface subsidence characteristics due to pillar extraction, and instrumentation of pillars to measure overburden and mining-induced stresses. Dr. Chugh is cooperating with Heinz Damberger of the ISGS Coal Section in the second year of a project to identify characteristics of Illinois mines in regard to their geology and mine stability problems.

Time Domain Reflectometry, *Bauer, Brutcher, J. Kelleher, B. Mehnert, and Van Roosendaal* Investigators continue to develop a simple way to monitor subsidence movements in bedrock. Recordings from two coaxial cables that were grouted into boreholes over the longwall panel in Jefferson County have documented the progressive movement of bedrock strata up to ground surface. Another cable was installed at the Saline County longwall site. Also, a cable was installed over an abandoned mine undergoing subsidence. The subsidence event is damaging a grade school in Collinsville, Illinois. As with the earlier studies, Dr. Charles Dowding of Northwestern University assists with these investigations. A draft final report on this project was submitted and returned with comments from the funding agency, the Office of Surface Mining.

Mined-Out Areas, Urban Lands, and Population Density, *C. Treworgy, Hindman, and Bargh* This project evaluated the proximity of underground mines (coal and other minerals) to urban areas. For each county in the state that has had some underground mining, tables and maps were prepared showing the acreage of urban land and number of housing units that are close to mines and may be exposed to risk of subsidence. The final report on this project was delivered to the sponsor, the Illinois Mine Subsidence Insurance Fund (IMSIF). Open file copies of this report are available to the public. A summary of the project is being prepared for publication in the ISGS Environmental Geology series.

Minerals Associated with Mine Subsidence, *Hughes, Moore, and DeMaris* Roof and floor strata in Illinois coal mines often yield during or after mining and may cause hazards within the mine and at the surface of the earth. Clay mineral content and the abundance of expandable clay minerals are suspected causes of these failures. Two studies have been undertaken to determine the degree to which measures of mineralogical content correlate with engineering test data and the actual occurrence of failures. An explanation of the fundamental causes of failure may help prevent future problems and suggest remedial procedures for existing problems.

Explosive Gases

Geochemistry of Natural Gas, *Riley, Coleman, and Liu* At the request of the Illinois Department of Mines & Minerals, a site was visited in Livingston County where gas was reportedly boiling up through the water in a shallow dug water well and flowing from a newly drilled well. Samples of the gas were collected and tests for combustible gas were made in the basement of the adjacent house and outside the house around the foundation. No combustible gas was detected in or near the house. This site overlies a gas storage field in an area where drift gas (bacterially produced methane within the glacial drift) is common. The gas company was contacted and they provided us with samples of the gas from their storage field. Analysis of the samples showed that the escaping gas was storage gas, and the gas company has now undertaken steps to control the problem.

At the request of the homeowner, a site was visited in Champaign County. The basement sump had "caught on fire" and a portable gas detector indicated a high percentage of combustible gas venting from the sump a day later. One cause could have been drift gas, which is common in the area. However, analysis of the gas samples showed that the problem was caused by a leaky pipe connecting a propane fuel tank to the home. The homeowner has replaced the damaged pipe and had no further problems.

Rock Mechanics and Geotechnical Support Studies

Determination of True Orientation for Tiltmeter Study, *Su* ISGS is modifying a mainframe computer program to a PC version to determine the true orientation for tiltmeter. The tiltmeter can be applied to study many engineering geological and geotechnical problems, including trench-cover performance, subsidence slope and strain calculations, and landslide studies. The program is interfaced with Oracle Database for data storage and management and output to AutoCad for graphical presentation.

Sodic Soils in Illinois, *Su and Stohr* Sodic soils that are delineated in soil surveys have engineering implications that have not been compiled previously in a useful format. Because these soils are very dispersive, they may be unsuitable for use in engineering projects such as earth dams and landfills. In Illinois, sodic soils occur in 25 counties and cover 240,700 acres. The data to ensure that sodic soils are excluded as borrow materials for future engineering constructions are being made available through a PC-based database system that combines mapping and database software. Mapped distributions of sodic soils, acquired from soil surveys, are digitized using Autocad, computer-aided design software, and interfaced with Oracle, software for data storage. The system provides easy archival and updating routines to query locations and sizes of sodic soils in any user-request area. Sodic soil distribution maps also can be generated at any scale.

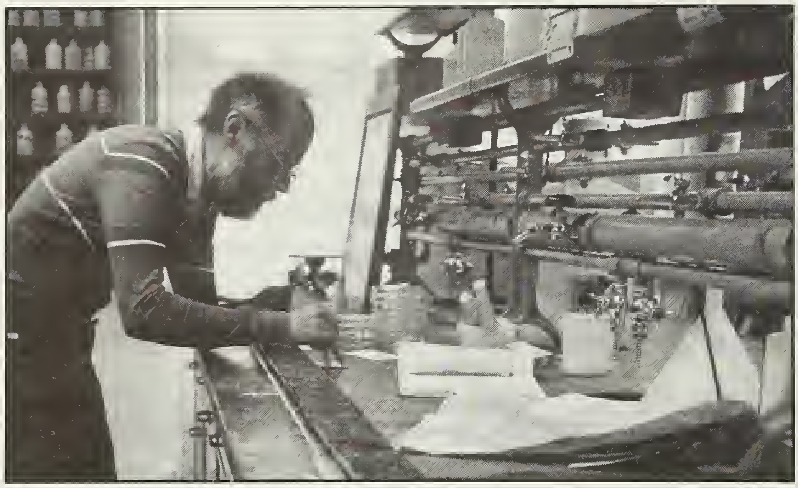
Technology Transfer and Information Services

Mine Subsidence Information Dissemination, *Trent, Bauer, and DuMontelle* A workshop was held at Southern Illinois University at Carbondale in conjunction with the Illinois Mining Institute in September 1989. The objective was to instruct Illinois mine operators in the use of the SIUC subsidence-prediction model for room-and-pillar mining. Participants gained hands-on experience using the computer program, and some mining personnel brought geotechnical data from their own companies to estimate subsidence.

The IMSRP display was exhibited at the Illinois Mining Institute, and in October, at a board meeting of the Society for the Illinois Surveys (SISS). At both meetings, copies of IMSRP publications were on display, and researchers were present to answer questions.

Bibliographic searches on the IMSRP database were filled in response to requests from industry, researchers, and consultants. A 1988-1989 update of the IMSRP bibliography was prepared for the Illinois Mining Institute. IMSRP publications have been requested from Australia, Belgium, Canada, Colombia, India, Iran, Mexico, Turkey, Venezuela, and Yugoslavia.

Computer-Assisted Directory of Mine Subsidence Insurance Claims, *Coates, Hindman, Schwartz, Bauer, and DuMontelle* The Illinois Mine Subsidence Insurance Fund (IMSIF) supports the PC-INFO database of mine subsidence insurance claims from the entire state. Funding for the directory has continued since 1983, and now more than 4,100 records of claims are in the database. Included are data on structure type, causes of damage, location of insured structures, and information on underlying mines. The database is searched to answer questions concerning under of subsidence events in an area or over a specific mine.

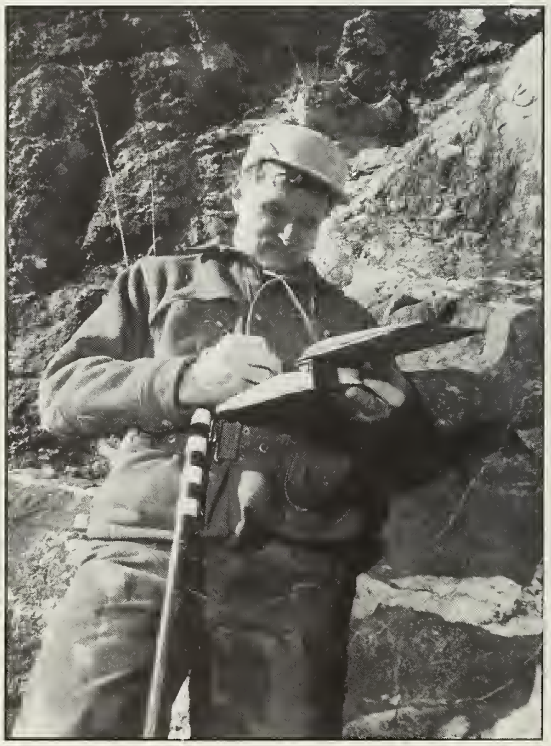


A

B

(A) Richard Cahill, Analytical Chemistry, prepares samples from a core section to measure their cesium-137 content. (B) Pius Weibel, Coal Section, and Dave Reinertsen, Educational Extension, examine an outcrop along the south bank of the Embarras River. (C) Mineral and Engineering staff monitors the continuous aggregate coal flotation process that removes ash from coal. (D) John Nelson, Basin and Crustal Analysis, takes notes on an outcrop of a fault and fluorspar vein near Eddyville.

C



D

General and Basic Research

GENERAL AND BASIC RESEARCH

General and basic research includes programs of wide applicability—from mineral resources and engineering to environmental geology and geochemistry. Many fundamental investigations in stratigraphy, structural geology, and paleontology lead to applications before the research is completed. General and basic research also provides a framework for applied studies of mineral resources and the environment; for example, biostratigraphic investigations provide an important tool for correlating coal beds, thus aiding in calculations of coal resources and facilitating coal exploration. Studies in glacial geology provide information that has wide application—from locating shallow aquifers to helping scientists, engineers, and planners understand the timing, magnitude and causes of lake-level fluctuations. Study of the earth's crust beneath Illinois and adjacent states is leading to knowledge of the deep structures along which earthquakes occur and to the definition of deep oil and gas plays. Results of studies on the distribution of sedimentary rocks in time and space provide insights into the evolution of the Illinois Basin and an understanding of our surroundings.

CRUSTAL STUDIES

Studies of the character of the earth in and around the Illinois Basin provide knowledge of the nature of the crust, the processes that led to the origin and development of the Illinois Basin, and the distribution of the natural resources in the basin.

Knowledge of the Midcontinent crustal framework has increased significantly in recent years as a result of regional geophysical studies. Such studies include deep seismic reflection profiling across the Illinois Basin by the oil and gas industry and by the Consortium for Continental Reflection Profiling (COCORP), deep seismic reflection profiling in the Reelfoot Rift portion of the New Madrid Rift Complex by the U.S. Geological Survey (USGS), and gravity and magnetic maps of Illinois produced through a cooperative effort of the ISGS and the USGS. Analyses of the data from these studies are far from complete, and in some cases, acquisition of more data is planned. Clearly, there is a need for additional deep seismic profiling in and around the New Madrid Rift Complex. The National Seismic Network, a joint venture between the Nuclear Regulatory Commission and the USGS, includes plans to install several permanent seismograph stations. The USGS will select the best location for new seismometers in Illinois using data provided by the ISGS. Information from these seismometers will enhance regional knowledge of the earth's crust beneath Illinois.

Industry-sponsored reflection profiling has focused primarily on Phanerozoic rocks that contain the state's mineral resources. The ISGS is making an effort to acquire these and other proprietary geophysical data to increase its seismic library, a vital database for basin analysis.

Potential Field Data

Statewide Gravity and Magnetic Maps, *Heigold* Aeromagnetic maps at scales of 1:1,000,000 and 1:500,000 and gravity maps at scales of 1:500,000 and 1:250,000 for the entire state of Illinois have been compiled through a cooperative effort between the ISGS and USGS. These maps, currently in review, provide information about the structure and composition of earth's crust.

BASIN ANALYSIS

The Illinois Basin covers approximately 60,000 square miles in the southern two-thirds of Illinois and adjacent parts of Indiana and Kentucky. The basin contains about 100,000 cubic miles of sedimentary rocks that yield valuable resources, including industrial minerals and metals, coal, oil, and gas. These resources have benefitted the state's economy for many years. Basin analysis, a multidisciplinary method of research, contributes to the discovery and development of mineral resources in Illinois by providing information on the geologic framework of the Illinois Basin and thus improving predictions of mineral resource occurrences.

The ISGS Basin Analysis Program integrates geological and geophysical data to increase understanding of how the basin formed, filled with sediment, and changed after burial. The primary focus of research during the report year was on (1) construction of cross sections showing the structural and stratigraphic framework of the basin, (2) quantitative modeling to determine the mechanisms of tectonic subsidence in the Illinois Basin, (3) stratigraphic analyses of selected Cambro-Ordovician rocks to determine relationships between rock types of the same age, (4) completion of a compendium on the structural features in Illinois, (5) conodont biostratigraphy of selected lower Paleozoic rock units to facilitate rock correlation, (6) correlation of Ordovician volcanic ash beds, and (7) completion of a text on interior cratonic basins that features the Illinois Basin. To capitalize on existing facilities and expertise, the ISGS has continued its cooperative research programs with the Indiana and Kentucky Geological Surveys, as well as with the USGS.

Framework Studies

Illinois Basin Cross Section Project, *J. Treworgy and Whitaker (ISGS); Noger (Kentucky Geological Survey); and Furer (Indiana Geological Survey)* Work on a grid of 20 regional cross sections representing the Illinois Basin subsurface is in progress. The cross section network will provide an up-to-date portrayal of the stratigraphic, structural, and paleoenvironmental framework of the Paleozoic rocks in the Illinois Basin and contribute to the planning and effectiveness of hydrocarbon and other mineral exploration. The ISGS project is being coordinated with similar work at the Indiana and Kentucky Geological Surveys. The first four cross sections were produced, peer reviewed, and revised during the report year. Preliminary copies were presented at the annual meeting of the American Association of Petroleum Geologists in Bloomington, Indiana. Open-file blue-line copies will be available to the public. The cross sections will be published when all have been completed and checked for consistency.

Silurian Litho- and Biostratigraphy in Northeast Illinois, *Mikulic and Norby* Exposures of Silurian rocks in northeast Illinois are being studied to increase understanding of regional geology and promote development of the aggregate resources of northern Illinois. This work includes study of quarry exposures, natural outcrops, and diamond-drill core held by ISGS, Metropolitan Water District of Greater Chicago (MWDGC), and private companies. The goal is to establish a reference section of litho- and biostratigraphic features of the Silurian rocks of the area that will be the basis of local and regional correlations. The extensive database being developed should be useful to the local crushed stone industry.

Tennessee-Illinois-Kentucky Lineament (TIKL): A Possible Megasuture Between Precambrian Terranes, *Heigold and Kolata* The Tennessee-Illinois-Kentucky Lineament (TIKL) is a dominant feature on the aeromagnetic map of the east-central Midcontinent U.S.A. This lineament, which crosses the southern part of the Illinois Basin, consists of a band of high magnetic gradient bordered on the north by a series of closed magnetic highs that have been interpreted as Precambrian-age mafic intrusions into the upper crust along a zone of crustal weakness. From a regional perspective, magnetic values north of TIKL are relatively higher than those to the south of the lineament. Recently acquired COCORP and proprietary seismic reflection sections in the area of the magnetic lineament show prominent layering in the Precambrian basement north of the lineament and little or no layering south of the lineament. North-south seismic reflection sections across the TIKL show a series of diffraction patterns between 1.7 and 5.0 seconds, whose source probably represents the southern margin of a Precambrian crustal plate. The TIKL appears to represent a megasuture between Precambrian terranes. Reactivation of this zone of weakness may have been responsible for formation of the Cottage Grove Fault System and other major geological structures in the southern part of the Illinois Basin.

Evolution of Sedimentary Basins (ESB), a Cooperative Study Between the Illinois Basin Consortium (IBC) and the U.S. Geological Survey (USGS), *Kolata and staff* The Illinois Basin is one of six sedimentary basins being studied in the USGS Evolution of Sedimentary Basins Program. During March 1990, the Illinois Basin Consortium (Illinois, Indiana, and Kentucky Geological Surveys) and the USGS organized a joint 5-year investigation of the Illinois Basin. Four areas of joint research were identified: (1) mineral resource appraisal (industrial minerals and metals, coal, oil, and gas), (2) tectonic framework (including acquisition of seismic and potential field data), (3) flow paths and chemistry of basin fluids, and (4) database development. A summary of joint projects in progress was presented at the annual meeting of the American Association of Petroleum Geologists in San Francisco, California.

Structural Geology and Tectonic History

Structural Features of Illinois, *Nelson* The report, a catalog of all named structural features (such as anticlines, synclines, and faults) within the state, is an expanded and updated version of ISGS Circular 519 by J. D. Treworgy (1981). Nelson reviewed the evidence for each feature listed in Circular 519 and eliminated more than 150 previously named features, the existence of which is doubtful. About 30 newly named structures were introduced, and the names of others were changed in order to be consistent. The report includes a statewide map at a scale of 1:500,000, information about each named feature, and discussions of the tectonic framework and history of Illinois.

Tectonic Subsidence History of the Illinois Basin, *J. Treworgy, Sargent, and Kolata* The timing and rates of subsidence provide important clues about the processes involved in the evolution of the Illinois Basin. Subsidence history is fundamental to understanding how the basin formed, filled with sediment, and changed physically and chemically through time. These data are useful in constructing models for the maturation and migration of hydrocarbons and for the movement of ore-forming fluids. Quantitative modeling of the basin suggests that tectonic subsidence was controlled by rifting, thermal subsidence, and an isostatically uncompensated mass in the lower crust at the southern end of the basin.

A poster summarizing study results was presented at the Annual Meeting of the Eastern Section of the American Association of Petroleum Geologists in Bloomington, Indiana. It received the Vincent E. Nelson Memorial Award for the best poster at the meeting. Results of the study were also presented at the annual meeting of the American Association of Petroleum Geologists and at the North-Central Section Meeting of the Geological Society of America.

Stratigraphy

Cretaceous/Tertiary Boundary in Southern Illinois, *Masters, P. Reed, and J. Frost* ISGS scientists arranged a Cretaceous/Tertiary boundary field trip in southern Illinois for Alan Hildebrand (University of Arizona). Hildebrand is conducting isotopic, geochemical, and sedimentary research related to the theory that the impact of a comet or asteroid at a marine site in or near the Caribbean Sea terminated the Cretaceous Period. His theories, which include the cause of mass biological extinction, have received publicity in scientific publications and in the national media. The purpose of the trip was to search for additional evidence for this theory and find, describe, and sample sections at the northern limit of late Cretaceous marine transgression in southern Illinois.

Lithology and Geochronology and Elemental Analyses of Gulfian (Upper Cretaceous) and Paleocene Deposits in Illinois, *P. Reed, Masters, Glass (ISGS); and Hester (Indiana Geological Survey)* A postulated Cretaceous-Tertiary (K-T) boundary event coinciding with a giant meteor impact and/or vulcanism may have caused worldwide extinctions. Sedimentological characteristics of the K-T boundary have been studied at two exposures in the northernmost part of the Mississippi Embayment near the Ohio River in Pulaski County, Illinois. Comparison of trace elements has indicated a relationship with K-T boundary conditions reported from other parts of the Mississippi River Embayment, the Gulf Coastal Plain, and other parts of the world. Continuous samples were collected for potassium-argon (K-Ar) dates and research into the trace-element geochemistry of the deposits. New procedures in analytical chemistry are being developed for this project. A manuscript incorporating the sedimentological data and K-Ar dates is now being revised for publication in FY91.

Basinwide Study of the Caseyville, *Jacobson* The COGEOMAP (Geologic Mapping Program with the USGS) has increased understanding of the Caseyville Formation. Geologic mapping of Caseyville Formation exposures in southern Illinois will be extended to the subsurface. The Caseyville Formation is the first unit above the major sub-Pennsylvanian unconformity in the Illinois Basin. Thickness, lithologic variation, and regional distribution are being examined. Studies of cuttings have proved helpful. The first cross section has been completed; ideas and data have been exchanged with Lloyd Fuhrer, who has been working on a similar study at the Indiana Geological Survey.

A Common Formational Nomenclature for the Pennsylvanian of the Illinois Basin, *Jacobson, Weibel, and staff of the Coal Sections of the Illinois, Indiana, and Kentucky Geological Surveys* The first draft of a joint paper by the Tri-State Correlation Committee on the standardization of nomenclature for formations of the Pennsylvanian System was completed. The new terminology, adopted by all three geological surveys, replaces a plethora of terms that apply only within the political boundaries of each of the three states.

Correlation of Middle Ordovician K-Bentonite Beds (Altered Volcanic Ash) In Eastern North America, *Kolata (ISGS), Huff (University of Cincinnati), and Trevail (Telesis Oil Company)* Two widespread altered volcanic ash beds, the Deicke and Millbrig K-bentonites, have been correlated from northwestern Iowa to Birmingham, Alabama, to Montreal, Canada, covering about 500,000 miles of eastern North America. These beds are useful time lines that provide a previously unattainable level of accuracy in Ordovician chronostratigraphy. The correlations enable accurate construction of geologic structure maps and cross sections, as well as paleogeographic reconstructions used by oil and industrial minerals companies, among others. A paper describing the correlation of the Deicke and Millbrig beds was accepted for publication in the Bulletin of the American Association of Petroleum Geologists, and a paper was presented at the meetings of the North-Central Section of the Geological Society of America in Macomb, Illinois.

Tectonomagmatic and Stratigraphic Significance of Ordovician K-bentonite Beds in Eastern North America and Northwestern Europe, *Kolata (ISGS), Huff (University of Cincinnati), Bergstrom (Ohio State University), and Bauert (Estonian Academy of Sciences)* Ordovician K-bentonite beds have been correlated throughout eastern North America and are known to be present in parts of northern Europe, including Estonia, Sweden, and Norway. Current reconstructions of Ordovician-age paleogeography (450 million years ago) place Baltoscandia adjacent to the east coast of North America. A narrow seaway referred to as the Iapetus Ocean separated the two drifting continental plates. A system of explosive volcanic islands apparently was situated between the two landmasses. It is unclear, however, whether the same volcanoes produced the ash beds that are present in North America and Baltoscandia. Chemical analyses of the ash beds could provide information about the tectonic setting of the volcanoes from which the ash was derived and answer the question of whether the ash beds are correlative.

During the past year the National Science Foundation awarded a grant (administered through the University of Cincinnati and Ohio State University) to collect and chemically analyze K-bentonite samples from Estonia, Sweden, and Norway. The Estonian Academy of Sciences has also agreed to provide support for the project.

Paleoenvironmental Studies

Study of the Nature of the Pennsylvanian-Mississippian Contact, *Weibel and Norby* A detailed study of microfossils and stratigraphy of the strata straddling the Mississippian-Pennsylvanian boundary in southern Illinois resulted in an invited symposium paper and a proceedings paper, now in review. The recent drilling of a core as part of the COGEOMAP (Geologic Mapping Program with the USGS) through the Mississippian Grove Church Shale created the opportunity to reevaluate the biostratigraphy of strata at the boundary. Several recent studies of exposures of these strata yielded conflicting conclusions on the length of a hiatus at the contact between Mississippian and Pennsylvanian strata. Samples of the oldest Pennsylvanian Wayside Member of the Caseyville Formation and the youngest Mississippian Grove Church Shale were processed for extraction of microfossils. These fossils, primarily conodonts, were used to reevaluate the biostratigraphy, and the sedimentary structures and textures of the core were studied to determine paleoenvironmental conditions. Preliminary results indicate several disconformities in the interval that includes the boundary between the Mississippian and the Pennsylvanian; the disconformity at the boundary is minor at the cored location.

Herrin Swamp Paleoecology, *DeMaris, Nelson (ISGS); and Willard (Smithsonian Institution)* A paper on early Herrin Coal swamp development within a small paleochannel was presented at the Geological Society of America annual meeting in St. Louis in November. Peat accumulation began early within the paleochannel; cordaites and tree ferns dominated the earliest peat-producing floras in the channel. A manuscript is being prepared for publication.

Oakland Concretions from the Energy Shale, *DeMaris and Moore* This project will combine an analysis of the fossil flora found in coal concretions with a geochemical and mineralogic examination of the concretions and the enclosing shale.

Paleogeography of the Lower Tradewater of the Lower Middle Pennsylvanian in the Southern Illinois Basin, *Devera* The ancient geography of the Illinois Basin during this period of coal formation is being investigated by studying coals of variable extent and thickness found in the lower Mid-Pennsylvanian. The study will concentrate primarily on paleotopography, paleoclimate, sedimentology, and the tectonics of the basin at that time.

Synthesis

AAPG Interior Cratonic Basins Volume, *Leighton, Kolata, Oltz, Eidel, and staff* The ISGS staff contributed manuscripts and camera-ready illustrations for a major, comprehensive report on interior cratonic basins of the world. Half of the volume is devoted to the Illinois Basin as a prototype; the other half contains chapters on six other interior cratonic basins and a synthesis. The volume contains contributions from 62 geoscientists from the Illinois, Indiana, and Kentucky Geological Surveys, and academia and industry. This is one of five volumes to be published in the American Association of Petroleum Geologists (AAPG) Memoirs on World Petroleum Basins.

Insights into the geology, geophysics, and geochemistry of the Illinois Basin accompanied the compilation of this report. For example, the volume details the profound effects of plate tectonic on the evolution of supposedly stable interior cratonic basins. Analyses of the seven basins included in the volume, augmented with data from other well-known interior cratonic basins, indicate that these basins

- subsided nonlinearly and episodically at different times and places, generally over a span of several hundreds of millions of years,
- subsided during periods of either crustal extension or compression or both,
- were affected by directed stress fields propagated by plate tectonics,
- responded variably and differentially to the orientation and intensity of stress fields, depending on the alignment of older crustal inhomogeneities.

The interior cratonic basins contain multiple depositional sequences marked by major bounding unconformities. The major unconformities are tied directly to low stands of sea level; however, basin shapes and orientations (which vary in some basins with the development of each depositional sequence) appear to be tectonically controlled. Thus the low stands of sea level may also be tectonically controlled, perhaps enhanced or influenced at times by climatically controlled eustatic falls of sea level.

Basin forming, filling, and modifying processes directly and indirectly control hydrocarbon occurrences and recovery. The most important of these processes are

- repeated basin submergence and emergence, leading to development of multiple sequences bounded by major unconformities, coupled with basin reorientations and varying geometries over long periods of basin duration, creating numerous opportunities for the right combinations of source rocks, seals, reservoir rocks, and traps,
- fluctuating sea level coupled with low but nonlinear subsidence rates and generally adequate rates of supply that lead to rapid shifts of base level, widespread distribution of reservoir rocks, and facies changes conducive to the development of widely distributed stratigraphic traps,
- early rifts that helped to control later structural development and focus the maturation and migration of hydrocarbons,
- structural overprinting apparently induced by intraplate forces,
- recurrent structural movements associated with the evolution of interior cratonic basins.

Although considerable information is presented in the volume on the nature of interior cratonic basins and their contained oil and gas fields, unanswered questions are also setting a course for future research. The volume is slated for release by AAPG in March 1991.

The results of this project were presented to more than 500 scientists and students by M. W. Leighton in the course of an AAPG Distinguished Lecture tour to 17 institutions and geological societies in the United States and Canada this past spring. A summary of results of the volume was presented in a poster session at the annual meeting of the American Association of Petroleum Geologists in San Francisco, California, June 1990.

GEOLOGIC AND TOPOGRAPHIC MAPPING AND REMOTE SENSING

Geologic maps delineate the areal and vertical distribution and properties of earth materials used for environmental protection and mineral exploitation. The ISGS plans to expand its geologic mapping program significantly, parallel to plans of the National Geologic Mapping Program (NGMP). The NGMP will be patterned after the the National Topographic Mapping Program, which requires matching funds by the states. In June 1990, the Illinois Senate passed Resolution No. 881, regarding a state geologic mapping program. The resolution includes a request that the ISGS report to the Senate by January 1, 1991, on the status, need, and plans for a statewide mapping program.

Topographic mapping provides base maps at various scales, planimetric maps, and digital cartographic data that can be compiled with geologic and other thematic data, using a Geographic Information System (GIS). The short-term goal of the program is the completion of the 1:100,000-scale county map series. Interest has been expressed in accelerating the preparation of digital cartographic products, especially 1:24,000-scale digital elevation maps.

Remote sensing provides the aerial photography and remote-sensing imagery for data collection and analysis used in geologic, hydrologic, and mineral resources mapping. The short-term goals of the program are to use synthetic aperture, side-looking airborne radar (SLAR) for extrapolating structural features and identifing ancient archaeological (mound) sites. Another aim of the program is to cooperate with the University of Illinois Map and Geography Library to complete their collection of historical aerial photography and acquire a second collection of aerial photography for loan through the Illinois Research and Reference Service.

Geologic Mapping

Geologic Mapping Program In Southern Illinois, In Cooperation with the U.S. Geological Survey (COGEOMAP), *Damberger, Nelson, Jacobson, Devera, Weibel, Peppers, and DeMaris* Geologic mapping of fifteen 7.5-minute quadrangles in southern Illinois (carried out in cooperation with the USGS) is now nearing completion. These maps, all prepared at a scale of 1:24,000, will be published as standard, multicolor geologic maps of the bedrock geology. Six have been published to date. Each map is accompanied by a detailed geologic report.

- **Geologic Map of the Creal Springs Quadrangle,** *Trask, Jacobson, and staff* The Cartographic Laboratory of Northern Illinois University (NIU) completed scribing and color separation and delivered the four basic negatives to the printer.

- **Geologic Maps of the Eddyville and Stonefort Quadrangles,** *Nelson and Lumm* The Cartographic Laboratory of NIU completed scribing and color separation and delivered the four basic negatives to the printer.

- **Geologic Map of the Goreville Quadrangle,** *Jacobson* Reviews of this quadrangle were completed and a final draft was prepared and submitted to the NIU Cartographic Laboratory for scribing, color separation, and production of the four basic negatives.

- **Geologic Map of the Waltersburg Quadrangle,** *Weibel and Nelson* A final draft of this map was completed after revision based on comments by internal and outside reviewers.

- **Geologic Map of the Glendale Quadrangle,** *Devera* Review comments by team members and C. Rice of the USGS were taken into account in preparing a final draft of this map.

- **Geologic Map of the Bloomfield Quadrangle,** *Nelson* A draft map of this quadrangle was compiled on a greenline mylar base map. Technical review was completed, and the final map can now be prepared.

- **Geologic Map of the Makanda Quadrangle,** *Weibel and Jacobson* Geologic field mapping was completed and a draft geologic map for the portion of the quadrangle covered by the Mississippian Sytem was compiled on a greenline mylar base map.

- **Geologic Map of the Cobden Quadrangle,** *Nelson and Devera* Field mapping was completed, and a draft map is being compiled on a greenline mylar base map. Approximately half of this work has been completed.

- **Geologic Map of the Wolf Lake Quadrangle,** *Devera* Geologic field mapping was completed and a draft map compiled on a greenline mylar base map. This map will be completed at the same time as the map of the Cobden Quadrangle, because the geology of the two quadrangles is similar.

- **Geologic Map of the Lick Creek Quadrangle,** *Weibel and Nelson* Field work on this quadrangle was completed and the compilation of the draft map on a greenline mylar base map is in progress.

- **Geologic Map of the Gorham Quadrangle,** *Devera* Field work on this quadrangle is well advanced.

- **Geologic Map of the Altenburg Quadrangle,** *Devera and Nelson* Mapping of this quadrangle is nearly complete.

- **Geologic Report on the Creal Springs, Eddyville, and Stonefort Quadrangles,** *Nelson, Jacobson, Trask, Devera, Riggs, Follmer (ISGS); Esling, Lamon, and Henderson (SIU)* Review of this substantial report was completed. The chapter on the Quaternary geology of the quadrangles was significantly modified.

- **Geologic Report on the Goreville Quadrangle,** *Jacobson* This report, substantially revised on the basis of comments by internal and external reviewers, was in administrative review at the end of the report period.

- **Geologic Report on the Waltersburg Quadrangle,** *Weibel and Nelson* This report was completed and is in technical review.

- **Geologic Report on the Glendale Quadrangle,** *Devera* A draft of this report was completed and will soon be submitted for review.

- **Geologic Report on the Bloomfield Quadrangle,** *Nelson* This report was completed and reviewed and will be revised on the basis of the reviewers' comments.

- **Geologic Report on the Cobden Quadrangle,** *Nelson and Devera* About half of this report has been written.

- **Geologic Report on the Wolf Lake Quadrangle,** *Devera* The manuscript for this report is being drafted.

- **Diamond Drill Program,** *Damberger, Devera, Nelson, and Weibel* Drilling of two stratigraphic test wells in the Cobden Quadrangle was completed. These wells provided valuable information on the stratigraphy of rock sequences in the Mississippian System.

Cooperative Topographic Mapping by the U.S. Geological Survey (USGS) and the Illinois State Geological Survey New or revised editions of 175 7.5-minute topographic quadrangle maps have been authorized for northeastern Illinois (73), the Quad Cities (33), and southern Illinois (32). The mapping is funded by the USGS. A 30-map project in southern Illinois is funded by the U.S. Forest

Service. The remaining seven maps, along the Illinois-Indiana state line, are funded by the Indiana Department of Natural Resources and the USGS. Of the 46 maps in the 1:100,000-scale, 30x60-minute series, 29 have been converted to topographic format. In the 1:100,000-scale county map series, 57 maps have been published and 55 have been delivered to the ISGS.

Remote Sensing

Remote Sensing Investigations for Siting and Monitoring Landfills, *Stohr* At the invitation of the ASTM (formerly American Society for Testing and Materials), Stohr drafted and presented a guideline on this topic at the ASTM meeting in San Francisco in June.

Side-Looking Synthetic Aperture Radar (SAR), *Stohr (ISGS) and Wiant (Illinois State Museum)* After possible Indian burial mounds were defined on the SAR imagery, a field reconnaissance check was performed of the suspected archaeological sites. Field reconnaissance of the four sites was greatly enhanced by the use of new high-resolution aerial photography of the lower Illinois River supplied by the Illinois Department of Transportation. One of the sites was verified as a burial mound group. Researchers found that within the identified mound group, individual mounds with only a few feet of relief were displayed on the radar imagery and the aerial photography. The success in finding subtle mounds on the Illinois River floodplain using SAR flown at 40,000 feet is encouraging, indicating a potential to help locate Indian burial mounds. Plans to extend the search for sites along the lower Illinois River and into the uplands are under consideration.

QUATERNARY INVESTIGATIONS

Studies of the Quaternary deposits of Illinois are being refocused to provide an organized body of information in a form readily accessible to its users. The program of Quaternary studies includes data collection, classification, framework development, characterization, and mapping of the deposits, as well as development of a strong quality-control program. Many of the mandated activities and contract projects conducted by the ISGS require comprehensive knowledge of Quaternary materials.

Framework Studies

Reclassification of the Wedron Formation (Wisconsinan) of Illinois, *Hansel (ISGS) and W.H. Johnson (University of Illinois, Geology)* ISGS and University of Illinois staff are developing a reclassification of the Wedron Formation. New data have been collected and new ideas generated which may result in local and regional changes in the definition, nomenclature, and classification of the Wedron Formation. An early draft of a report, "The Wedron Group: A Revision of the Wisconsinan Wedron Formation, Lake Michigan Lobe Area," was presented to the staff of the Quaternary Framework Studies Section for comment and discussion in March 1990. The basic concept of elevating the Wedron Formation to Group status was accepted. Additional work will be required to define the formations and make appropriate nomenclatural changes necessary to elevate existing members to formational status.

Stratigraphy, Characterization, and Age Assessment of the Oldest Documented Quaternary Sediments in Illinois, *Follmer (ISGS) and B. Miller (Kent State University)* This is a cooperative project to collect and conduct analyses on test cores at the County Line (Adams/Hancock) Section north of Quincy, Illinois. Preliminary studies indicate that, on the basis of modern dating methods, the organic, fossiliferous silts overlying the limestone at this site are the oldest Pleistocene (Quaternary) sediments in Illinois; they are about 800,000 years old. Three tests cores collected in June 1990 were taken to Kent State University for selected analyses, including amino-acid analysis of snails and bone and teeth of vertebrates, and determination of the magnetic properties of the silts. The incomplete geologic record of these older Quaternary sediments in western Illinois indicates that large-scale erosion occurred during the Quaternary. The erosion appears to be related to or caused by the factors that initiate and accompany glaciation. This study may help to elucidate these factors as well as verify the age of the sediments at the County Line Section.

Geology and Hydrogeology of the Teays-Mahomet Bedrock Valley System, *Kempton (ISGS) and Melhorn (Purdue University)* Papers on the Geology and Hydrogeology of the Teays-Mahomet Bedrock Valley System have been accepted by the Geological Society of America for publication as GSA Special

Paper 258. The publication includes a paper, "Mahomet Bedrock Valley in East-Central Illinois; Topography, Glacial Drift Stratigraphy and Hydrogeology," by J.P. Kempton, W.H. Johnson (University of Illinoi), P.C. Heigold, and K. Cartwright.

Key Quaternary Stratigraphic Control, *Kempton and staff* This database, initiated during SSC wrap-up activities, is now a permanent program to assure adequate cataloging, archiving, evaluations, and quality control of all surface and subsurface data collected on Quaternary deposits throughout the state. In addition to data for the five-county SSC study area in northeastern Illinois, the database includes preliminary data for 30 other counties. The main emphasis thus far has been to develop computer techniques for inputting and retrieving the data.

Age of Sangamonian Vertebrate Fauna from the Hopwood Farm Site, Montgomery County, Illinois, *Curry and others* The age of Sangamonian vertebrate fossils has been determined by electron spin resonance in a cooperative study including B. Blackwell and H. Schwarez (McMaster University), J. Saunders (Illinois State Museum), and N. Woodman (Kansas State Museum). The fossils studied include a mastodon tooth, giant beaver tooth, and gar scales. The ages of the fossils range from about 108,000 to about 87,000 years ago. The results of the study were presented by Blackwell at the joint meeting of the American Quaternary Association and Canadian Quaternary Association held at Waterloo, Ontario, in June 1990.

Quaternary Environments and Processes

Subglacial Processes and Sedimentation Studies, *Hansel (ISGS), W. H. Johnson (University of Illinois), and others (Oregon State University)* This study of well-preserved subglacial bedforms from the Quaternary record showed clast plowing, lodgement, and glacier sliding over a soft bed. Study findings were published in *Boreas*. Work is continuing on this and related studies to understand and model the dynamics of large ice sheets and characterize their deposits. A paper, "Multiple Wisconsinan Glacigenic Sequences at Wedron, Illinois," was published in the *Journal of Sedimentary Petrology* during this reporting period.

Field Evaluation of Deformable Bed Model Work on understanding and modeling the dynamics of large ice sheets continues. ISGS staff presented a paper reporting on a preliminary evaluation of the deformable bed model in Illinois at the International Union for Quaternary Research (INQUA) symposium, "Control of Glacier Dynamics and Subglacial Landforms," held in Madison, Wisconsin in July 1989.

Fossiliferous Deposits and Woodfordian Sediments at Lomax, Illinois, *Curry and others* A unique fossiliferous sequence of deposits continues to be studied to determine sedimentological and floral changes during the last periglacial-to-glacial transition. Curry led a field trip discussion at Lomax and presented a paper on preliminary findings at the symposium on the Quaternary History of the Mississippi River valley during the annual meeting of the North-Central Section of the Geological Society of America in Macomb, Illinois, in April 1990.

Pre-Late Wisconsinan Paleolimnology and Ostracod Fauna of the Southwestern Great Lakes Area, USA, *Curry* This study, focussing on pre-Woodfordian lake sediments in central Illinois and their paleoclimatic implications, is designed to determine the paleohydrochemical changes that have occurred during one complete glacial-interglacial-glacial cycle over the past 150,000 years. To increase understanding of the changes indicated by fossil ostracodes, a modern collection is being prepared from collections taken from lakes elsewhere in the central U.S. during June 1990. The ancient record in Illinois is being studied by examining cores taken from drained lake basins near Fillmore, Vandalia; Raymond R. Baker of the University of Iowa is studying the fossil pollen and plant microfossils from these cores.

Database Enhancement

Key Stratigraphic Control System, *Mushrush, Kempton, and Berg* A database management system is being established to provide a wide range of information pertaining to controlled drilling operations and type sections. Databases will include information on locations, results of analyses done on samples collected, sequence of materials, and source of information. A map will be produced showing the location and identification number of key borings and exposures. The system is being designed using a relational database program that permits integration with other systems currently in use. This newly developed system will facilitate efforts in groundwater protection and other disciplines seeking key information relative to land use.

Technology Transfer

Quaternary Framework of the Lake Calumet Area, *Hansel, Kempton, and Miller* In a project requested and supported by the Illinois State Water Survey (ISWS), ISGS staff are contributing basic geologic information for the first part of a comprehensive evaluation of the occurrence, transport, and fate of groundwater contaminants in the Lake Calument area of southeastern Chicago. A preliminary report, bedrock maps, and cross sections were provided to the ISWS in November 1989.

A draft geologic report describing the Quaternary framework of the Lake Calumet area was submitted to the ISWS in June 1990 for incorporation into a draft contract report to the Illinois EPA. This geologic report included a map of the study area showing the lines of cross sections, six cross sections and updated maps of the bedrock topography and drift thickness. It also included a description of the distribution and characteristics of the drift units present and a discussion of the potential hydrogeologic conditions relative to groundwater and surface-water contamination. In June, three test holes were drilled and split-spoon samples were taken; ISGS staff assisted during the drilling and are describing the samples for the final report to IEPA.

Quaternary Framework of Ancona Gas Storage Facility, *Kempton* At the request of Bruce E. Engquist, Northern Illinois Gas, a study of Quaternary stratigraphy was undertaken at the Ancona facility site, where pipeline-quality gas had been encountered in water wells in the glacial drift. Core samples taken from three borings above the storage area were described, and the stratigraphic sequence was established. A report (including cross sections) was provided.

Scientific Exchange Field Tour, *Follmer and others* At the request of the Loess Commission of the International Union for Quaternary Research, ISGS staff organized a working conference field tour that originated in Peoria, Illinois, on July 21, 1989, and ended on July 25 at Baton Rouge, Louisiana. The tour visited key localities of loess exposures in the lower Illinois River valley and the lower Mississippi valley. The focus was on the stratigraphic interpretation of loess units and soils, their relation to paleoclimate, and the evidence for global climatic change. Technical sessions were held on two evenings to discuss tour observations and their relation to global climatic interpretations, and the loess-soil record of Canada, China, and Hungary. In the midcontinent region, key loess localities occurring in Illinois can be correlated to localities in Louisiana that directly relate to the major cycles of sea-level change resulting from the glacial-interglacial cycles during the Quaternary Period. Among the 39 participants were loess researchers and graduate students and three distinguished researchers from Canada, China, and Hungary.

Scientific Exchange with Geological Survey of Finland, Hansel (ISGS) and Ulpu Väisänen (Geological Survey of Finland) Six-month exchange visits began at the end of May and early June. Väisänen has already participated in a USGS project to test drill and describe samples for the Lake Calumet area and a field study with W. H. Johnson and E. Hajic (University of Illinois) along the middle Illinois River valley. The exchange should promote new ideas, methods, and fresh perspectives.

PALEONTOLOGY/PALYNOLOGY INVESTIGATIONS

These investigations focus on the use of information from fossils to date and correlate rock units and determine their environments of deposition.

Paleontology Studies

The Youngest Carpoid: Occurrence, Affinities, and Life Mode of a Pennsylvanian (Morrowan) Mitrate from Oklahoma, *Kolata (ISGS), Frest (University of Washington), and Mapes (Ohio University)* Carpoids are an extinct group of echinoderms. Abundant, well-preserved specimens of a new peltocystidan mitrate carpoid were found in the Pennsylvanian (Morrowan Series) in southern Oklahoma

The new carpoid postdates the youngest previously known carpoids (Middle Devonian) by about 65 million years. The presence of the carpoids in these rocks provides information about the depositional environments the shales in which the carpoids occur. A manuscript describing this new fossil was prepared and submitted to the *Journal of Paleontology.*

Taxonomic Study and Biostratigraphic Significance of the Mississippian Conodont Genus *Lochriea*, *von Bitter (Royal Ontario Museum) and Norby (ISGS)* This study redefines the Mississippian conodont genus *Lochriea* and increases its value as a biostratigraphic indicator. Several species, which will now be classified under this genus, have become very important for international biostratigraphic correlation. These species were not well understood previously because the constituents of each species were misidentified. The study is complete, and the manuscript is being prepared for publication.

Arthropod Fossil Record, *Mikulic* Arthropods are an important group of invertebrate animals characterized by jointed appendages and segmented bodies. Ancient trilobites and modern insects both belong to this group. A paper, "The Arthropod Fossil Record: Biologic and Taphronomic Controls on Its Composition," was prepared for publication as part of a Paleontology Society Short Course on Arthropods. A second paper, "Temporal Patterns of Arthropod Trace Fossils," was also prepared for the arthropod short course.

Ichnofossil Research, *Devera* Trace fossils as fossil tracks are valuable paleoenvironmental tools that can be used for establishing predictive models of regional environments of deposition, for instance, for coal seams or oil.

The collection and curation of trace fossils continues to expand. During the report period one scientific paper, two field trips, and one short course were completed. A paper, "Ichnofossils of the Lower Pennsylvanian of Southern Illinois," appeared in a field trip volume, one of the new Illinois Basin Series (IBS) published by the Illinois Basin Consortium.

Palynology Studies

Floral Community Variation in Basal Pennsylvanian Strata Overlying Paleokarst on Mid-Mississippian-Age St. Louis Limestone in McLure Quarry, Tennessee, McDonough County, Illinois, *Peppers* Investigators from Western Illinois University, Illinois State Museum, Smithsonian Institution, and Illinois State Geological Survey (Peppers) studied the stratigraphy, sedimentology, petrography, paleobotany, and palynology of these rocks to interpret their depositional history. The palynology of samples of the coal at the bottom of the section was used to interpret the paleobotanical development of the coal bed and to identify the coal as the Tarter Coal rather than the Manley Coal as had been previously thought. Composition of palynological assemblages does not reflect the differences in the two kinds of plant compression communities that overlie the coal. The results of the study were presented at the 1990 North-Central meeting of the Geological Society of America at Macomb, Illinois.

Palynological Correlation of Major Pennsylvanian (Upper Carboniferous) Chronostratigraphic Boundaries in Euramerica, *Peppers* This manuscript, summarizing much of the palynological research in the Illinois Basin and in other coal basins in North America and Europe since the 1930s, will be submitted to a journal after final review. A discussion of the major paleobotanical shift at the mid-upper Pennsylvanian boundary will be submitted as a separate paper.

Midcontinent Pennsylvanian Working Group of the Society of Economic Paleontologists and Mineralogists (SEPM), *Peppers (ISGS), Boardman and Barrick (Texas Tech), Heckel (University of Iowa), and Nestell (University of Texas at Arlington)* A paper on the mid-upper Pennsylvanian chronostratigraphic boundary in the Midcontinent of North America was submitted to a journal by members of the working group, including Peppers. Important changes that occurred in the stratigraphic distribution of conodonts, fusulinids, brachiopods, ammonoids, and spores at the boundary in the Midcontinent are demonstrated and compared with changes that occurred in the Illinois Basin and the Appalachian region.

Correlation of Spores with Parent Plants, *Peppers* Spores in a sporangia (a spore-bearing organ) attached to a specimen of a seed ferne cone, *Sphenopteris*, were identified as the isolated spore, *Apiculatasporites variocorneus*, for the first time. The specimen was studied at the request of the Illinois State Museum.

Palynology of Samples from Potential Low-Level Nuclear Waste Storage Sites, *Peppers* A sample of carbonaceous clay from an outcrop at the Martinsville site, Clark County, was analyzed to determine its age, but no spores were found. Two coal samples from a core drilled at the Jeff site, Wayne County, and a sample from a nearby quarry were also studied. The quarry sample was identified as the Calhoun Coal. One of the coals in the core was identified; the other coal is very thin, and only an approximate identification was made.

Palynology of Clay Deposits in the Des Plaines Tunnel, Cook County Sanitary District, *Peppers* Several samples of clay from cavities within rocks excavated during construction of the Des Plaines Tunnel were analyzed to determine the age of the clay, but the samples contained no spores.

Palynologic Correlation of Coals in a Core from Vendenburg County, Indiana, *Peppers* Samples of the Seelyville, Houchin Creek, Colchester, Springfield, and Hymera Coals and of a coal thought to be the Danville Coal from a core in Indiana, near the border to Illinois, were studied to determine how they correlate with Illinois coals. The coal called the Hymera Coal was correlated with the Herrin Coal of Illinois. A second sample of the Hymera Coal from its type section is being analyzed to learn whether Hymera is equivalent to the Herrin. The coal nearest the surface in the Indiana core is not the Danville; it was correlated with the Allenby Coal.

Use of Palynology in Interpretation of Structural Geology, *Peppers* Several coal samples from opposite sides of a faulted area were analyzed to determine their ages and provide a correlation across a major fault in the southeastern part of the Illinois Basin. The coals are younger than previously thought. The results of the study will be included in a paper by Nelson and Lumm.

Palynologic Correlations for Cooperative Geologic Mapping Project (COGEOMAP), *Peppers* To assist field mappers, ten samples of lower and middle Pennsylvanian coals were studied to identify and correlate coals in the quadrangles being mapped in Pope and Williamson Counties.

Technology Transfer and Information Services

Management of the Paleontological Collections, *Norby* Loans of fossil material were made to researchers from nine academic or research institutions across the United States, Canada, England, and Australia.

Paleontological Society Short Course on Arthropods, *Mikulic* A Paleontological Society short course on arthropods will be held in conjunction with the Geological Society of America Annual Meeting in Dallas, Texas, in October 1990. Mikulic organized the short course, selected the 14 speakers, coordinated manuscript reviews, and made other necessary arrangements for the one-day course. Peer review and preliminary editing were completed during the reporting period.

GEOCHEMICAL INVESTIGATIONS

Geochemistry, the union of geology and chemistry, covers a broad field extending even into such areas as microbiology and atmospheric studies. Geochemical research is included in all ISGS research areas. Much of this research is described under the program in which it is being applied. A few geochemical studies that are basic in nature or involve one or more programs are described here.

Shale Geochemistry

Characterization of Aromatic Hydrocarbons from Oil Shale Extracts by Tandem Mass Spectrometry, *M. Chou (ISGS) and Wood (Purdue University)* Chemical comparison was made of the soluble aromatic fraction of shales from the New Albany (Devonian-Mississippian) and from the Green River Formation, Colorado. Characterization of the organic components (such as biological markers) in the extracts from the two shales is of geochemical significance because the molecular structures of biological markers could (1) predict the level of thermal maturation of the organic materials, (2) help define the depositional environment of the sediment, (3) be linked to the structures of precursor compounds occurring in source materials, and (4) be useful in petroleum exploration and fossil fuel utilization. These study data suggest that the New Albany shales are generally more mature than the Green River. This paper was presented at the 16th Annual Meeting of the Federation of Analytical Chemistry and Spectroscopy Societies, October 1-6, 1989, Chicago, Illinois.

Biogeochemistry

Kinetic Isotope Effects Associated with Fermentation-Derived Acetate and Relationships to Sedimentary Biogenic Methane, *Risatti* The ISGS has entered into a joint project with scientists from Indiana University (UI) to develop a model to explain the flow of carbon in the formation of methane in anaerobic sediments. This research should increase understanding of the formation of landfill gases and the formation of methane in sediments. At the ISGS, acetogenic bacteria have been grown on carbon dioxide; the acetate product and the methane produced from the cleavage of acetate by methanogenic bacteria has been collected at various time points. The substrates, cell mass, acetate, and methane from the experiments were sent to the IU group for stable carbon isotopic analyses. From these data and the data from field experiments, a manuscript on methanogenesis in lake sediments was completed with J. Gelwick (Mercke, Incorporated) and J. Hayes (IU). In the second phase of this project, in conjunction with the ISGS Isotope Geochemistry Laboratory, acetogenic bacteria will be grown autotrophically and heterotrophically to determine the stable carbon and hydrogen isotopic compositions of the acetate product.

Coal Geochemistry

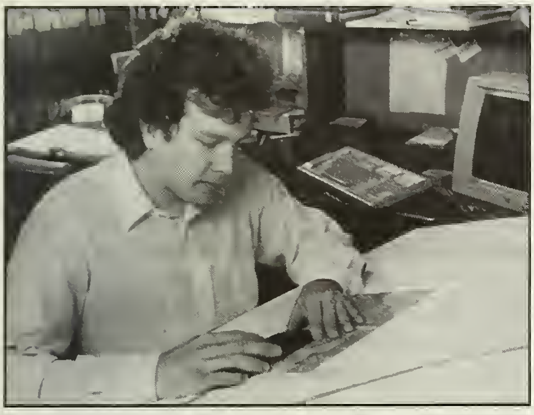
Organic-chemistry and Geochemistry of Coal and Coal Related Strata, *M. Chou, C.-L. Chou (ISGS); and K. V. Wood (Purdue University)* The sulfur content in the Herrin (No. 6) Coal in Illinois is related to the sedimentary environments of roof strata. Coal overlain by relatively thick, nonmarine, gray Energy Shale has a lower sulfur content than does coal that is overlain by marine strata of the Anna Shale and Brereton Limestone. Organic geochemical data on coal and its related strata may permit better prediction of sulfur variations in coal.

In this reporting period, immature Anna Shale from the Hillsboro coal mine in Montgomery County, Illinois, was analyzed for polar components—compounds that contain oxygen, nitrogen, and sulfur. The shale, deposited in a marine regime, contains high concentrations of metalloporphyrins (nitrogen-containing organic compounds complexed to specific metals such as nickel and vanadium). Previous analyses have indicated that the concentrations of metalloporphyrins in nonmarine Energy Shale are low to nondetectable. A communication of this study has been accepted for publication in *Energy and Fuel.*

MINERALOGIC INVESTIGATIONS

With the help of "Build Illinois" funding, several ISGS contracts, and GRF support, the ISGS continues to maintain a world-class laboratory for mineral studies. This laboratory supports a wide range of projects within the ISGS and assists Illinois citizens as well as industry, government, and the scientific/academic community. Mineralogical analyses are used to tell landowners whether their earth materials have potential value for industrial products, identify changes that occur in earth materials and disrupt the state's mineral industries, and contribute to the solution of environmental problems such as waste disposal. Upgrades of the computer operating system for the Scintag X-ray diffraction system and the acquisition of specialized grinding and sample-preparation equipment under the Illinois grant for improved oil recovery have led to improvements at the ISGS in advanced quantitative analysis of minerals and synthetic substances.

The research aspect of mineralogical investigations includes studies of clay minerals in soils—studies that (1) help to reconstruct the paleogeography and climate during ancient times of soil formation, (2) predict the suitability or capacity of materials for the isolation or absorption of hazardous wastes, (3) indicate areas of geotechnical hazard or increased stability, and (4) evaluate soils for clay products, crop

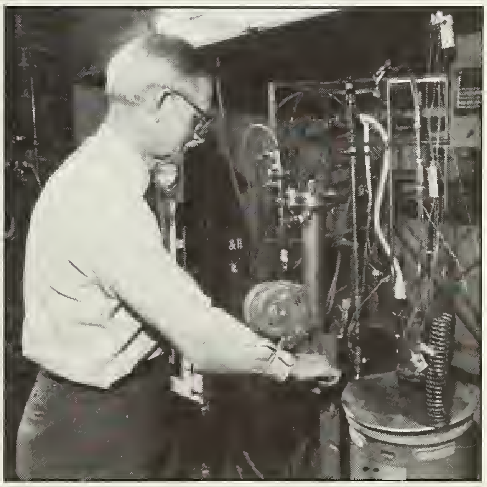


A

(A) Robert Krumm, Computer Research and Services Section, digitizes a soil map in preparation for another map on shallow geologic materials for the Champaign County landfill siting. (B) Keith Hackley, Isotope Geochemistry, explains the pyrolysis/combustion system for coal research. (C) Scenic Bailey Bluff, east wall of the Mississippi River, at Pine Hills Recreation Area in Union County. (D) Carl Kruse, Minerals Engineering, produces hydrocarbon liquids by coal gasification.

B

C



D

substrates, or uses such as pond liners. The first question asked about candidate waste sites is the nature of Quaternary rock units. Most studies at such sites extend existing regional geologic frameworks that are largely the result of earlier mineralogical investigations.

The detailed structure of the clay minerals, illite and chlorite, is believed to indicate the sources, age, composition, and flow path of solutions in the subsurface. Further investigation is warranted.

Research Studies

Soil Clays, *Hughes, Moore, Glass (ISGS); and Reynolds (Dartmouth College)* Soil-forming processes that result in distinctive changes in mineralogical composition are being investigated to identify mineralogical "signatures" indicative of particular soil types, record the intensity and duration of soil formation, and reveal similarities and differences between modern and ancient soil occurrences. The goal of this research is to use knowledge of soils to reconstruct paleogeography, provide stratigraphic controls, and locate economically valuable clay deposits. This year's developments include locating new samples containing poorly crystallized kaolinite and mixed-layered kaolinite/expandable (K/E). Although still considered rare, the clay mineral, K/E, has been found in paleosols of various ages in Illinois. Recent efforts have shown that the variety of K/E that forms is a reflection of the clay mineral "parent" materials. Contrasting parents yield products with distinctive composition and X-ray diffraction (RX) signatures. ISGS scientists and Professor Reynolds have begun a cooperative effort to write an improved computer program to model the XRD spectrograms of samples containing K/E and provide theoretical and calculated XRD intensity factors for comparison with natural samples.

Clay Mineralogy of Coal-Related Strata, *Hughes, DeMaris, and White* Final editing of a chapter on underclays by Hughes, DeMaris, and White for a book on paleosols or ancient soils, has been completed.

Iron Sulfide Mineralogy for Coal Desulfurization, *Hughes, Moore, M. Chou, and Glass* Desulfurization of coal, using carbon monoxide and ethanol or thermal treatments, involve steps that convert pyrite/marcasite to pyrrhotite. Other minerals within coal can enhance or retard coal conversion reactions. A greater understanding of these minerals, especially pyrrhotites, essential for process improvements has been gained by using X-ray diffraction analysis to identify the minerals in feed coals and process products. The goal is to measure the degree of mineral-matter removal by a specific treatment or processing step and suggest improvements in the process to take advantage of mineralogical properties of the coals. An investigation of the nature of the pyrite-pyrrhotite reaction during reduction with hydrogen or carbon monoxide gas was completed, and varieties of pyrrhotite that might be used for various catalytic reactions were determined. Data from X-ray diffraction and Moessbauer analyses of pyrrhotite varieties were compared. A publication on pyrrhotite determination by the two methods is planned.

Quaternary Geology by Mineral Composition, *Glass, Moore, and Hughes* The mineral composition of Quaternary deposits and their associated soils is being used to reconstruct their depositional history. Most of this year's efforts have been directed to improving methods of quantitative analysis of the minerals in these strata. An invited paper on methods is in preparation for the annual meeting of the American Society of Agronomy, the Soil Science Society, and the Soil Science Society of America. This paper will be published as part of a symposium volume.

Native American Artifacts Made from Berthierine in Whiteside County, Illinois, *Hughes, Moore, Berres, and Bish (Los Alamos National Laboratory)* Berthierine, a rare clay mineral with a structure similar to kaolinite, has been found to be the raw material for a wide range of Native American artifacts from northwestern Illinois. The occurrence of artifacts suggests that the area around Sterling, Illinois, was the geological source of this material. The material is distinctive enough that it will be possible to trace it through ancient trade networks. To increase understanding of the nature of this rare mineral, efforts are being made in association with D. Bish to determine its structure. The tendency of berthierine to form in a hard claystone that can be carved suggests that it has structural similarities to kaolinite. Because of its hardness, this material was thought to be flint clay, a variety of kaolinite. Flint clay is commonly associated with coals. Kaolinite is the only clay mineral, until this occurrence, known to form a carvable claystone.

Mineralogy of Chlorites, *Moore, Hughes, and Glass* Chlorite minerals affect the porosity and permeability of petroleum reservoir rocks. They are often important reactants to fluids introduced into reservoirs, causing man-induced decreases in porosity and oil production. To quantify the impact of these minerals, investigations are underway on both the chemical and physical constitution of chlorites. Small amounts of serpentinelike (soapstone) mixed-layering in the chlorites from Aux Vases and Cypress sandstone oil reservoirs have recently been identified and efforts are being made to estimate the iron, aluminum, and magnesium contents of chlorites. Findings of these studies will be correlated with the flow properties of the rocks. Previous investigations have indicated that iron contents of chlorite determine its reactivity with agents used to complete and enhance production from oil wells.

XRD Laboratory Improvements for Mineral Analysis

Improved XRD Procedures, *Hughes and Moore* Research during the report year has focused on improved quantitative analysis of the mineralogical composition of clay-bearing rocks and minerals. Refinements in quantitative analysis of the common nonclay minerals (quartz, orthoclase, plagioclase, calcite, dolomite, and pyrite) made it possible to correct clay-mineral quantitative data for iron versus aluminum and magnesium substitution in illite, illite/smectite, and chlorite.

Quality Assurance/Quality Control Procedures for Quantitative Mineralogical Analysis by X-Ray Diffraction, *Hughes and Moore* Written procedures for quality assurance/quality control were completed. They include how to sample, when to use blind analyses for control, how to prepare and analyze samples, and how to interpret and report results. An outgrowth of these procedures is the current effort to design databases and reporting forms that will provide consistent formats for all types of X-ray diffraction analyses.

Preparation of a Manual for the X-Ray Lab, *Moore* This manual, now being revised, is designed to be a user-friendly guide to the use of the X-ray laboratory machines. It describes standard methods of sample preparation and provides information necessary for the service and maintenance of the X-ray equipment. The manual will be available in FY91.

Technology Transfer

X-Ray Diffraction and the Identification and Analysis of Clay Minerals, *Moore (ISGS) and Reynolds (Dartmouth College)* A book by this name was published in October 1989 by Oxford University Press, (335 p.). The book has been well-received by clay scientists throughout the world.

COMPUTER RESEARCH

Computers and other hardware utilized for research activities at the ISGS include Prime minicomputers, Sun, Vax, and Silicon Graphics workstations, pen and electrostatic plotters, film recorders, digitizers, graphics terminals, and other devices. The Computer Research and Service Section (CRSS) is continuing its work on the construction and maintenance of tabular and graphic databases; in specialized software, such as ARC/INFO, INFO, ISM, IVM, Oracle, Z-Map (product names—no endorsement implied), programming languages, and assorted PC software; computer system design; software and hardware evaluation; project design; and the applications of computers to geoscience problems and to the development of the Geographic Information System (GIS) for the ISGS and the Illinois Department of Energy and Natural Resources. Recent focus has been on the use of ARC/INFO to produce and display maps of subsurface geology in complex glacial terrains; this effort has led to new data-management approaches that provide the geologist with workmap summaries of large amounts of well data and to improved efficiency of geologic map production. Future goals are to expand access to computing resources via a department-wide network and to improve the capabilities of computer systems for analysis and visualization of the subsurface.

Programming and Data Entry Research

Development of Computer-Assisted Geologic Mapping Techniques for Environmental Assessments, *McKay, L. Smith, Pool, and Krumm* Computer-assisted mapping techniques developed with ARC/INFO facilitate geologic mapping from the data resources available in the files and publications of the ISGS. The goal of this program is to enhance the interpretive abilities of the geologist by using the computer to prepare workmaps that contain virtually all the useful geologic data that exist for a given area. At the same time, the project is developing new types of maps to portray the complexities of near-surface (less than 400 feet deep) geology. The new map, a "slice" map, is a hybrid type of stack-unit map that displays the lithology and stratigraphy of a number of intervals below the ground surface. In the computer a "stack" of 15 "slices" becomes a computer model of the entire glacial drift succession to a depth of 400 feet. The utility of these maps is in environmental assessments and resource evaluations. Most siting and resource evaluation criteria are couched in terms of depth. For example, areas underlain by sand greater than a specified thickness and in a specific depth range are often excluded from consideration as a landfill site. The distribution of sand and gravel aquifers is readily outlined from the relationships expressed in the slice map set.

Development of Tools for Computer-Assisted Cross-Section Construction, *McKay* Using ARC/INFO (product name—not an endorsement) and automated well databases developed for the Champaign County mapping project, computer specialists are developing procedures for the computer-assisted construction of cross sections from well data. The system allows retrieval and display of well log and lithologic descriptions. It also allows the interactive assignment of stratigraphic correlations from a graphic terminal display and the storage of the correlations in a relational database for later use in mapping software. The system will be linked to menus for selection of wells, interactive and iterative correlation from graphic displays, and output of x,y,z data to contouring and volume modeling software.

Conversion of Computerized Programs to New Software System, *Denhart, Lecouris, and Yeko* At the ISGS, software systems in use on the Prime computer (system common to all divisions of the Illinois Department of Energy and Natural Resources) are being converted to run under new software on a Micro Vax 3800 computer acting as a database server. A commercial database package, Oracle, was installed on the Vax and will act as an engine to drive data entry and retrieval systems across a heterogeneous network. Conversion of systems used by the Geological Records Unit should be completed in 1991.

Technology Assessment

Volume Modeling and Contouring Software for Geologic Applications, *McKay, Pool, and Krumm* The ISGS took delivery of a Silicon Graphics computer workstation (funded through "Build Illinois") running Dynamic Graphics' Interactive Surface Modeling and Interactive Volume Modeling software (product names—no endorsement implied). These tools have been used to develop three-dimensional views of subsurface geology by producing three-dimensional models of geologic units and the variation of properties within them. Initial tests of the equipment have consisted of modeling the complex lithologic variation of Quaternary deposits in Champaign County. The tools will greatly enhance the geologist's ability to understand complex subsurface conditions by three-dimensional visualization.

Computer Systems

Installation of Natural Resources Building Ethernet Network, *Wilson, Witzany, and McKay* In cooperation with the Illinois Natural History Survey (INHS), the University of Illinois Office of Telecommunications, and the Computing Services Office, the CRSS has completed installation of a building-wide Ethernet communications network. Full implementation of the system will allow computer-to-computer transfer of files, disk sharing, and more sophisticated network operations. The inhouse network is connected to the University's optical fiber network to allow direct access to all University computing resources and to national and international networks. The network is implemented on a thick Ethernet backbone tied to the twisted-pair phone wiring, so that connection of individual offices to the network requires only a connection to an existing phone jack. The system will greatly increase the accessibility of ISGS and other computing resources to the ISGS staff. In addition, assistance was provided to several ISGS personnel in the establishment, maintenance, and troubleshooting of their communications hardware and software, ranging from the Ethernet connections to assistance with the Annex multiplexed dedicated lines.

New Computer Room, *Wilson, McKay, Witzany, and Kaczanowski* A new computer room was designed and constructed with GRF computer-based research funds. A system for humidity and temperature control system was installed for environmentally sensitive hardware. The separate room, which also houses noisy computer hardware to isolate it from personnel, is centrally located on the second floor of the Natural Resources Building for easy access by staff. Located in the room are the electrostatic plotter, pen plotters, high-speed printers, and database computer.

Acquisition and Installation of the SUN Sparcstations, *Wilson, Pool, and McKay* Two SUN Sparcstation computers with ARC/INFO (product names—no endorsement implied) software were acquired and installed in the Computer Research and Services Section for the use of ISGS staff. The workstations expand the availability of computing power on the GIS, facilitating computing tasks that cannot be accomplished on the overused Prime computers.

Database Computer System Design, *McKay, Wilson, Denhart, Treworgy, and Yeko* The Database Computer Subcommittee of the Computer Committee completed its evaluation of several computer systems for use as the ISGS "database computer." Recommended specifications included speed, disk capacity and speed, number of users served, backup device, compatibility, memory, operating system, and other factors. A Vax 3800 was purchased and installed with Oracle software for relational database implementation.

Technology Transfer and Information Services

Geographic Information System (GIS) Demonstration, Workshops, and Training, *CRSS staff* Demonstrations of capabilities of the GIS have been given for Champaign City and Champaign County Assessor Office staff, Lake County officials, Soil Conservation Service employees, ISGS visitors from Russia, and U.S. Geological Survey GIS staff. CRSS staff have presented talks concerning GIS applications at several local, regional, and national meetings including the Illinois Geologic Mapping Advisory Committee Meeting, the Midwest and National Arc/Info Users Conferences, the Association of Soil Conservationists, the Issak Walton League, and the Annual Geological Society of America Meeting.

ISGS Mailing Lists, *Junkins, Benner, and Denhart* The ISGS maintains mailing lists containing names and addresses of more than 20,000 people who receive ISGS publications. This year, one of the larger lists was separated into nine smaller lists on the basis of responses to a questionnaire, pinpointing the topical interests of recipients; this will reduce mailing costs by directing publications only to those truly interested in receiving them.

Quality Control of Paper Records Received by the Geological Records Unit (GRU), *Denhart, Zelinsky, and Faber* For each oil and gas well drilled in Illinois, well drillers must submit specific paper records to the ISGS on the basis of criteria set by the Illinois Department of Mines and Minerals. Each day these paper records are received by the GRU, matched with the well they pertain to, and entered into a computer database system located on the Prime 9955 computer. A record of each change or addition to this database is printed and used to verify the quality of the database. More than 70 lists have been created and used for this purpose.

SCIENTIFIC SUPPORT SERVICES

Few research or service projects can be successfully carried out by one team, section, or branch. Support of scientific programs requires a wide variety of services—from chemical and mineralogical analyses, to computer programming and maintenance, to review and publication of research findings.

Significant improvements and advancements have been made in several of the ISGS analytical laboratories and in its computing capabilities, by adding and improving capabilities. This year, particular emphasis was placed on standardizing and documenting quality assurance/quality control programs throughout the ISGS.

To keep abreast with the expansions and changes that have occurred in ISGS research and services, the Ad Hoc Committee on Publications proposed revised procedures for review and publication of project results. These changes include new definitions for some existing ISGS publication series and addition of some new series.

Quality Assurance/Quality Control

Quality Assurance/Quality Control Committee, *Dreher, Harvey, Chaven, C.-L Chou, J. Frost, Herzog, and Roy* Sixty-one standard operating procedures (SOP) describing laboratory and field techniques used in the acquisition of quantitative data were submitted to the QA/QC Committee. The SOPs were written in fulfillment of part of the overall QA/QC plan for the ISGS. QA/QC plans for specific projects and services that either produce or lead to the production of quantitative data are being written.

Ad Hoc Committee on Sample Data Management, *Harvey, R. Wilson, Dreher, Denhart, Chaven, Hensel, Su, and Goodwin* The committee developed a procedure to enter the required and recommended items for describing samples for inclusion in the Tested Samples Database. Problems were identified by different ISGS laboratories, and provisional solutions were agreed upon. A report on the procedures for Survey-wide use is in preparation.

Recommendations on Publications, *Publications Committee* The Management Committee accepted the recommendations of the Ad Hoc Committee on Publications charged with the task of reviewing and defining publication series for the ISGS. The Committee reviewed the publications series to determine whether the needs of the ISGS were being addressed. This review indicated that several series have gradually changed over time. For example, the Environmental Geology Note series, which began as a mimeograph note for quick release of environmental information, has developed into a Circular-level publication. Publication methods now enable the ISGS to rapidly print high-quality materials, making it unnecessary to define the purpose of a series by the quality of the printing. Adopted recommendations of the Committee were as follows:

- Retain topical series: Environmental Geology, Illinois Minerals, Illinois Petroleum, and Circular (which will serve as a miscellaneous topical series).

- Continue to publish exceptionally long-lived or comprehensive works in the Bulletin series; encourage authors to use this series.

- Set up annual and recurring publications in their own format, rather than include them as part of another series. Thus, *Illinois Minerals Industry*, *Petroleum Industry in Illinois* (in two parts), *Directory of Illinois Mineral Producers*, and *Additions to the Geological Samples Library* will have annual or recurring editions but will not be numbered as part of any series.

- Initiate a new series, Special Reports, to be an outlet for issues papers, histories, proceedings, atlases, and other "special reports." This series will not have a standard format.

- Establish an Open File Series for reports, maps, and other media. This will contain materials that require immediate release or which, for financial or other reasons, might not be published in the future. Two finished copies of these reports and/or maps will be placed on file in the library and reproduced on demand. These reports may be announced and copies may be sent to the USGS Library for inclusion in the AGI bibliographic literature. There will be no automatic distribution.

- Discontinue the Contract/Grant series. These reports will be assigned to the Open File Series or other appropriate series.

- A second map series in addition to the quadrangle map series will be developed for publishing broad regional and statewide maps. The series numbering system will take into account maps that are already published, for example, the *Quaternary Deposits of Illinois* and the *Geologic Map of Illinois*. A separate Cross Section series will be established.

The Committee emphasized that publication is a major part of project planning; consequently, project planning should include consideration of the end product (reports and maps) at the beginning of the project. The Committee also defined the publication series including Bulletins, Circulars, Environmental Geology, Illinois Mineral, Illinois Petroleum, Illinois Mine Subsidence Program, Guidebooks, Special Reports, Educational Extension Geological Field Trip booklets, Reprints, Illinois Scientific Joint Reports, Illinois Basin, Illinois Quadrangle, Illinois Map, Illinois Cross Section, and Open File.

Analytical Chemistry Services

Remodeling of several of the analytical chemistry laboratories was completed to ensure safe working conditions and to provide improved capabilities for support services to ISGS scientists and allied institutions. Analytical chemistry services include atomic absorption spectrophotometry, instrumental neutron activation analysis, optical emission spectrography, analysis of air and natural gas for radon, cesium-137 determinations, energy-dispersive and wavelength-dispersive X-ray fluorescence analyses, inductively coupled plasma emission spectrometry, packed column and capillary column gas chromatography, gas chromatography/mass spectrometry, high-performance liquid chromatography, infrared spectroscopy, nitrogen and carbon dioxide surface-area determinations, carbon content and variety determinations, Rock-Eval pyrolysis measurements, and various wet chemistry and miscellaneous techniques.

Isotopic Geochemistry Services

Isotopic Analysis Service Laboratory, *Liu, Hackley, Riley, Hwang, and Coleman* During the report period, carbon and oxygen isotope analyses were completed on 934 samples and sulfur isotope analyses were performed on 399 samples. Approximately 13 percent of these samples were for QA/QC and standardization purposes. Of the carbon and oxygen isotopic analyses, approximately 53 percent were for research projects at the University of Illinois, 17 percent were in support of the Radiocarbon Dating Laboratory, and 17 percent were in support of various ISGS research projects (natural gas identification, coal ball study, and others). Of the sulfur isotopic analyses, approximately 75 percent were for a study of the sulfur geochemistry in the Herrin Coal, 25 percent were for a joint USGS-ISGS CUSMAP project, and the remainder were analyzed in connection with coal desulfurization studies.

In the same period, experimental work to optimize the H_2O-Zn reaction for deuterium-hydrogen (D/H) isotopic analyses was successfully concluded. A reproducibility of 1 per mil for D/H ratio determinations has been achieved both for the standard stopcock-type reactor and for a much more convenient disposable sealed-tube reactor (¼-inch OD pyrex tubing). The development of a new procedure for determining $^{18}O/^{16}O$ ratios for water samples using serum bottles for H_2O-CO_2 equilibration is currently underway.

Radiocarbon Dating Laboratory, *Liu, McMillion, and Coleman* Radiocarbon (^{14}C) age determinations are provided as a service to both the geological and archaeological communities in Illinois. The ISGS operates the only Radiocarbon Dating Laboratory in the state (and one of only two in the Midwest) and thus provides a valuable service not only to other ISGS scientists, but also to educators and researchers throughout the state. During the reporting period, 160 radiocarbon age determinations were performed. Among the samples processed were 41 groundwater samples related to the Martinsville and Geff alternative sites project, and 16 landfill gases. Samples of particular interest dated in the reporting period include a piece of wooden support board from an Egyptian mummy (University of Illinois Museum), and tree trunks collected from a buried forest in Lake Michigan sediments. Approximately, 70 percent of the samples processed were funded by research projects. The unfunded 30 percent were primarily in support of the ISGS Quaternary research and graduate student projects at the University of Illinois.

Inter-Survey Geotechnical Laboratory

Inter-Survey Geotechnical Laboratory, *Miller and Roeper* A new Joint Operating Agreement was approved and signed by the Chiefs of the Illinois State Water and State Geological Surveys to state clearly the operational guidelines for the Inter-Survey Geotechnical Laboratory.

During the reporting period the following analyses were submitted and completed: suspended sediment concentration, 3651; full particle-size analysis, 243; sand fine split/clay sieve, 122; sand/silt/clay breaks, 0; moisture/unit weights, 0; and sieve tests, 210.

Other Analytical Support Services

Coal Analysis Laboratory Service, *Chaven and staff* During the last year the coal laboratory analyzed 690 samples with an average of five analytical tests per sample. Eighty-six samples were run on the Microtrac Particle Size Analyzer. The lab continues to participate in two monthly round-robin analytical programs for quality control as well as running internal control samples. The ISGS is the depository for

ASTM round-robin test samples. Coal laboratory personnel maintain the samples and distribute them to requesters. Illinois Basin Coal Sample Program (IBCSP) maintenance, distribution and record keeping are also performed by coal lab personnel.

Low-Temperature Ashing Laboratory Service, *Lowry* Fifty-four samples were processed in the ashing laboratory during the year to assist coal research projects.

SEM Laboratory Service, *Lowry and Harvey* The SEM laboratory was used on 176 occasions during this period by three ISGS operators, for approximately 528 hours. This laboratory is jointly supported by the ISGS and the Illinois Natural History Survey (Dr. Lee Crane, cosupervisor).

Computer Services

Microcomputer System Design, Setup, and Troubleshooting, *Witzany, Lecouris, Yeko, and Riley* Assistance was provided to more than 100 Survey employees in the last fiscal year. This service included the acquisition and installation of nearly 20 microcomputers, the installation of and basic training in the use of tens of software packages, and the upgrading and troubleshooting of more than 10 other microcomputers.

Computer Printing of Map Products, *Stiff* Using the new Calcomp (product name—implies no endorsement) electrostatic plotter, the staff completed production of 20 copies of the map, *Principal Aquifers of Illinois.* These copies will be part of a series of traveling exhibits to libraries throughout Illinois. Production of the map is the first test of the use of the plotter for "publication" of maps.

Human Resources System Development, *Lecouris* An Oracle-based system for human resource management was developed and installed to replace the outdated DBASE version. This system consists of 35 programs totaling more than 29,700 lines of "C" code. Preliminary system documentation was completed.

CONQuEST Demonstrations, *Yeko* Numerous demonstrations of the CONQuEST system were given to various state and private meetings, including an extended 1-week display at the Annual Convention of the American Association of Petroleum Geologists, a 1-day demonstration/discussion at the Ohio Geological Survey, and presentations to the U.S. Department of Energy (DOE) steering committee, Department of Public Health, and numerous private individuals.

Database Enhancement

Continued Enhancement of Computerized Well Information, *Denhart, Junkins, and Helm* Computer programs were designed, written, and used to confirm the completeness of the computerized database of well location information by searching for any assigned number not contained in the computer database. Once identified, missing well records were located and encoded. Additional efforts include entry of water well driller's lithologic data, well data used in the Knox County Land Report, and information on reworked wells.

MINERS Database: Restore and Convert, *Denhart and Helm* In the late 1970s, ISGS staff wrote a database entry and retrieval system (MINERS) containing geologic and geochemical studies data for the U.S. Department of Energy (DOE). Because of the rapidly expanding computer software industry, more "user friendly" software packages have found widespread use in the ISGS. The data from the MINERS system is being restored from magnetic tape and merged with other Survey data and will be used with newer software packages.

Data Entry of Recently Released Confidential Coal Records, *Junkins, Denhart, Zelinsky, and Faber* The ISGS Coal Section obtained permission to release more than 600 confidential coal records to the public. These records were entered using existing software on the Prime computer (of the Illinois Department of Energy and Natural Resources) and will be merged with other data.

Groundwater Database Activities, *E. Smith and staff* ISGS staff continued to organize and develop an automated groundwater database and reconcile problems found within water-well records and permits, utilizing those records and other subsurface information on file at the ISGS. The purpose of this project is to develop a base of subsurface data that will be more easily accessible to ISGS staff and others who require this information via a computer network. Currently, staff are entering water-well records into the database system. The format of the database was developed by staff of the Groundwater Sections in conjunction with the Geologic Records Unit.

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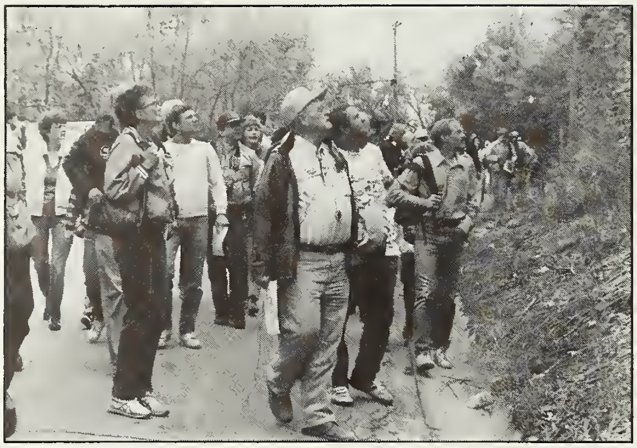

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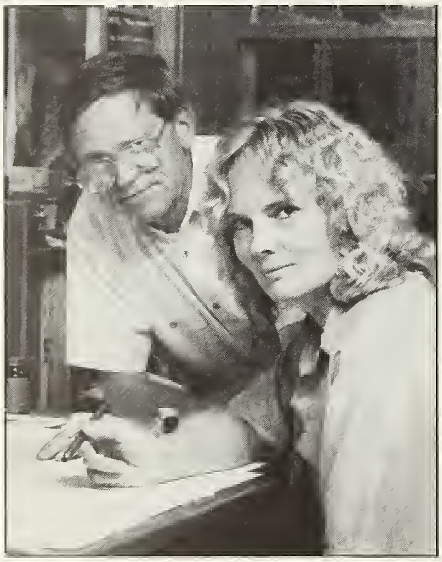

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(A) ISGS Educational Extension officer Dave Reinertsen (foreground, center), guides a group of geology buffs on a geological science field trip. Suzanne Muckensturm (left), public liaison officer, looks on. (B) At the Marine Bank in Springfield, students view a display, "Geological Influence on Biodiversity," produced jointly by the Illinois State Geological, Natural History, and Water Surveys. (C) Richard B. Berg, Montana Bureau of Mines and Geology, and Ulpu Vaisanen, Geological Survey of Finland, were exchange visiting scientists at ISGS this year. (D) Grand Tower looms before the Coal Section's Joe Devera—on a field expedition to map the geology of southern Illinois. (E) Oil and Gas display of ongoing research at the annual meeting of the Illinois Oil and Gas Association.

Technical and Administrative Services

TECHNICAL AND ADMINISTRATIVE SERVICES

Vital operating functions support ISGS research and service programs: budgeting, accounting, and financial reporting; contract and grant preparation and monitoring; timekeeping, counseling, and advising human resources; cataloging, searching, and locating library references; receiving and distributing incoming mail, commodities, and equipment as well as processing orders and shipping publications, maps, and other materials; maintaining the information office and the Illinois affiliate office of the National Earth Science Information Center; conducting public field trips, dealing with a variety of inquiries, and distributing educational materials; overseeing media and legislative relations; fabricating, maintaining, and repairing scientific, office, automotive, and other equipment and instruments; arranging changes in telephone programming and billing; providing editorial, graphic, typographic, duplicating, and other publications services; and planning and supervising new construction and building renovations.

The Geological Records Unit and the Geological Samples Library also provide vital technical services to research and service at the ISGS and to the public and private sectors. The documentation of Illinois geology maintained by these two units and the Reference and Map Library is the heart of ISGS activities and a basic source of information for private industry, government agencies, and the general public.

TECHNICAL AND ADMINISTRATIVE SERVICES BRANCH OFFICE

Branch Office staff provided secretarial services for the Technical and Administrative Services Branch, recordkeeping for the Contracts and Grants Office, document transfers between the NBI and WordPerfect word-processing systems, troubleshooting on the NBI, and telephone system changes and billing for the ISGS. They handled requests for maintenance performed by the University of Illinois Physical Plant, vehicle reservations, mail distribution, and loan copies of out-of-print ISGS publications. They served as an interface between the ISGS Administrative Branch and various departments of the University of Illinois. They assisted the Information Office, Mail Room, Business Office, Human Resources, and the Chief's Office when their respective staff members were on leave.

Responsibility for telecommunications also rests with the Administrative Branch Office staff. In addition to reporting problems with telephones, they handled required changes in telecommunications and billing for each personnel move within the ISGS. Telephone service orders were generated for each transfer of jacks between rooms or buildings; each jack's location and its active or inactive status was recorded. As personnel were added to or moved from one contract and grant to another, corresponding phone billings were also shifted to reflect the changes.

For the Contracts and Grants Office, records of University of Illinois employees, contracts and grants, and proposals were kept on WordPerfect and the NBI.

Draft copies of press releases, reports, contributions to outside journals and newsletters, fact sheets, correspondence, updates to the Calendar of Events and special meeting literature prepared by the Public Liaison Officer were finalized for printing or release by the Branch Office staff. During peak production periods, both staff members assisted with this work.

On the basis of a 3½-month sampling, the mail count projected for the report period amounted to 74,412 pieces of mail handled and 4,983 items received for the Library. These figures show a decrease in mail handling of more than 5,300 pieces, while Library receipts dropped approximately 325 items since FY89.

Whatever the problem—burned-out light bulb, broken door lock or adjuster, malfunctioning elevator or radiator—the Technical and Administrative Branch Office staff prepared requests for maintenance and service from the University of Illinois Physical Plant. This staff also updated the telephone list and hall staff directories.

BUSINESS AND FINANCIAL SERVICES

During this reporting period, the Business and Financial Services Unit (B&FSU) was awarded the Geological Survey's Special Achievement Award in recognition of its noteworthy contributions to the effectiveness and efficiency of the research and service programs in Fiscal Year 1989.

The unit was successful in implementing a program allowing payroll deduction privileges for parking fees at the University of Illinois. This program has been very well received with 35 percent of state-funded staff participating in the first year.

Throughout the year, the unit continued to fulfill its fundamental responsibilities of budgeting, purchasing, vouchering and accounting for all state appropriated and allocated funds of the ISGS as well as purchasing, vouchering, accounting, and providing budgetary support for all sponsored research funds of the Survey. As a result of the weaknesses noted in the biennial external audit, procedures for the collection and maintenance of property control records have been significantly improved and more clearly defined. These changes are also expected to continue to improve the efficiency of the unit.

In its continued effort to improve efficiency, the B&FSU went on line with the Comptroller's Inquiry System and the Illinois Procurement System. The on-line access to the Comptroller's Inquiry System allows rapid processing of inquiries from and payments to vendors. The on-line access to the Illinois Procurement System has allowed expediting of purchasing by significantly decreasing the time required to obtain purchase orders, authorizations and amendments.

The unit was instrumental in facilitating the purchase of a variety of complex scientific equipment and computers under FY90 "Build Illinois" funding. Much of this equipment required highly technical justifications and presented new and unique purchasing problems.

The Business and Financial Services Unit operationalized the new system for recovery of reasonable and allocable direct expenditures associated with general services rendered in support of sponsored research activities. This new system has provided support for the additional services required by the large proportion of state-funded contracts and grants at the Survey. Two staff members were added to the unit in April 1990 as an integral part of this program, which has also allowed the addition of support staff in other areas of the ISGS. The unit also experienced one staff turnover.

In FY90, the computerized accounting system of the B&FSU was upgraded and expanded through the addition of four 386/20 MHz computers. This new equipment provides expanded processing capabilities, speed, and improved data collection and storage.

GRANTS AND CONTRACTS

The Grants and Contracts staff aids in identifying new sponsorship opportunities as well as all phases of proposal development, including internal procedures, submission, approval, agreement development, contract terms and conditions, contract monitoring and some phases of administration—all under the guidelines of the University of Illinois and Board of Natural Resources and Conservation.

The new system for recovery of reasonable and allocable direct expenditures associated with general services rendered in support of sponsored activities at the ISGS is monitored and implemented by grants and contracts staff. After implementation of an agreement, the accounting function is transferred to the Business and Financial Services Unit.

The staff also provides microcomputer support for Grants and Contracts and the Branch. This includes equipment justification, system implementation, and trouble shooting of computer problems for several units in the Branch.

HUMAN RESOURCE OFFICE

Considerable effort was given to updating the Human Resource Office's (HRO) database from dBase III to Oracle, during the last reporting period. Documentation has been written, and the two staff members are learning the new procedures. CONQuEST, a computer program which allows easy retrieval of data for reports, has also been added to the system.

All personnel files (active and inactive) have been centralized in HRO's larger quarters (room 129) into which the staff moved in November 1989. The additional space also allows several staff or job applicants to complete required forms at the same time.

Along with changes in the State's life and health insurance, new procedures were established by the Department of Central Management Services (CMS) for the Benefits Choice Period, resulting in an independent company holding one-on-one meetings with all staff members. New procedures were also initiated for the Employee Assistance Program, requiring training for the Acting Human Resource Officer.

The HRO received 565 applications in response to 77 searches to recruit new staff. Of the 77 searches, 65 were for University of Illinois (UI) contract-funded positions, and 12, for state-funded positions, of which seven were for temporary posts funded by the Lands Unsuitable for Mining Program (LUMP). Letters were written to all applicants informing them of the status of their candidacy. Five requests to transfer UI contract-funded staff to state-funded positions were made to the Director. (On June 26, 1990, a hiring freeze for state-funded positions was executed.) New recruiting procedures are being established and will be implemented during the upcoming reporting period.

Other personnel activities performed by the HRO staff included the processing of eight termination and 84 status-of-participation reports. The office also processed 36 Deferred Compensation applications/changes, 56 changes on tax cards, and 101 changes of insurance. In addition to completing these forms, the HRO personnel answered 312 inquiries from staff members and distributed 110 benefit forms.

Linda Cunningham was named Acting Human Resource Officer while Marilyn Rebecca was on disability leave.

Activity Measures for Human Resource Office, July 1, 1989 - June 30, 1990

Personnel Activities	*1988 - 1989*	*1989 - 1990*
Open searches/recruitment	51	77
Advertisements placed	17	37
Professional journals	1	6
Newspapers	16	31
Announcemnts posted	89	77
Applications received	1,028	958
Response to ads and postings	622	565
Others	406	393
Candidates interviewed	101	349
New state appointments processed	15	0
Resignations/terminations (state)	9	5
Retirements	1	3
Exit interviews	22	26
New contract personnel	48	48
Contract personnel separations	43	21
Letters of inquiry regarding employment	1,154	958
Requests for approval to search/transfer	6	18
Requests for exception to hiring freeze	5	1
Requests for temporary appointments	12	0
Benefits		
Data changes on all insurances	81	84
Data changes on tax cards	22	36
Deferred comp applications/changes	152	110
Forms distributed to staff	261	312
ID cards processed	85	56
Staff inquiries (state/contract)	116	101
Status of participation reports (SURS)	349	360
Termination reports (SURS)	4	8

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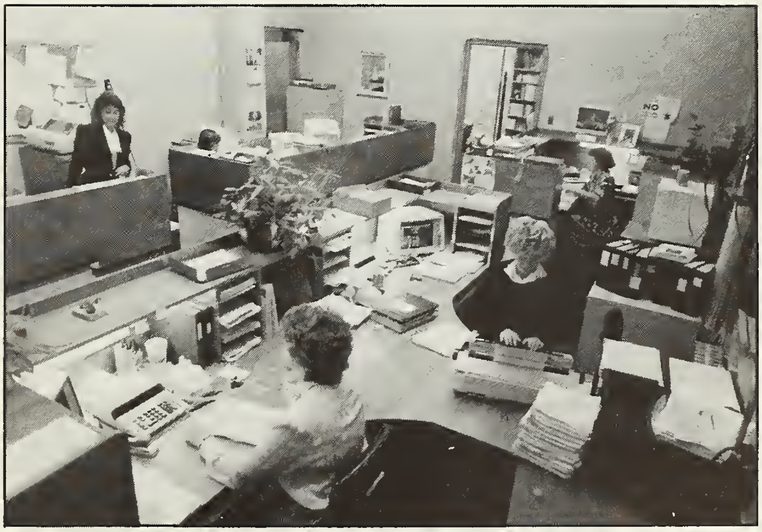

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(A) LeAnn Benner, Public Information Office, determines postage for mailing a map. (B) Linda Cunningham of Human Resources, compiles affirmative action data for a workplace analysis report. (C) Kristi Mercer, librarian in charge of the Map Room, replaces an atlas. (D) Business and Financial Services runs smoothly in the comfortable surroundings of custom-designed office units constructed by ISGS Technical Design, Operations, and Maintenance. (E) Photographer Joel Dexter and graphic artist Pam Foster select slides for a poster presentation.

LIBRARY/MAP ROOM AND PUBLIC INFORMATION

One additional staff member was added to the unit this year and assigned to both the Mail and Map Rooms. This person has allowed greater flexibility and will relieve the work overload.

Planning for a sales and inventory computer system network for the Public Information portion of the unit culminated in the selection and purchase of the Great Plains Accounting System and three additional PC's. This next year will be devoted to bringing the system on line.

Preparation of the List of Publications with a new subject index was completed and is being printed. This major effort involved the Library, branch secretarial services, Information Office, Mail Room, Publications, and the Print Shop.

Library/Map Room

The Library/Map Room provides reference services to the ISGS staff. Journals, bibliographies, acquisitions lists, and other materials are routed to alert staff members to developments in their fields. Citations are completed and verified; bibliographies prepared; online literature searches run; articles, books and reports located and borrowed; and staff are instructed in the use of the campus libraries as well as the ISGS library.

Because of seriously limited space, the Library remains in an overall no-growth position, and acquisitions have again decreased. Reference requests have increased, especially requests for verifying difficult citations and obtaining the materials.

Library Operating Statistics

Acquisitions	*1989-1990*	*1988-1989*
Total number	2,021	2,045
Books	130	80
State documents	405	496
U.S. documents	337	573
Canadian documents	57	64
Miscellaneous documents	125	227
Manuscripts	21	50
Maps	852	547
Photos, slides, and miscellaneous	94	8
Total items withdrawn	82	108
Serials titles and newsletters received	315	313
Library circulation		
Total number	2,734	3,185
Books, documents, serials, miscellaneous	1,829	1,929
Maps	590	991
Field notebooks, photos, slides, miscellaneous	208	87
Interlibrary loans (lent)	107	178
Journal routing		
Periodicals routed	1,662	1,769
Tables of contents routed	422	462
Interlibrary loans (borrowed)		
Total number	766	778
• from U of I libraries	330	200
• through Lincoln Trail Libraries System	292	318
• direct from other libraries	144	260
Reference questions	1,945	1,504
Online bibliographic searches	63	42
Visitors	272	278
Outside phone requests	201	158

Earth Science Information Center (ESIC)

Cooperative Topographic Mapping: New or revised editions of 175 maps in the 7.5-minute, 1:24,000-scale quadrangle series have been authorized in four separate projects. The largest projects--73 maps in northeastern Illinois, 33 maps in the Quad Cities area, and 32 maps in southwestern Illinois are funded entirely by the U.S. Geological Survey (USGS). A 30-map project in southern Illinois is funded by the U.S. Forest Service. The remaining seven maps, all of which are on the Illinois-Indiana state line, are funded by the Indiana Department of Natural Resources and the USGS. Of the 46 maps in the 1:100,000-scale, 30' x 60' series, 29 have been converted to topographic format. In the 1:100,000-scale county map series, 57 maps have been published and 55 have been delivered to the ISGS.

Information Office

The Information Office is the central office for handling public inquiries. General inquiries about the Survey from visitors or people calling or writing are handled by its staff. More detailed questions are referred to appropriate scientists. The staff also handles over-the-counter sales and processes orders for ISGS maps and publications and USGS maps covering Illinois. This office is also responsible for bookkeeping of sales, development of publication and announcement mailing lists, response to claims, and cooperating with the Publications Unit to determine press runs based on anticipated sales and distribution of the Survey's publications.

Several major distribution lists were reviewed and upgraded this year, and press runs have been adjusted accordingly.

A comparison of the Information Office's sales for fiscal years 1989 and 1990 showed a revenue increase of nearly $7,000. Map sales, especially USGS topographic maps, were largely responsible for this increase.

Mail Room

The Mail Room is the central receiving and distribution center for the ISGS. Shipments are handled, office supplies are ordered and stocked, and inventory control of equipment is maintained. Filling and shipping mail/phone orders and bulk mailings are also handled there. In addition, stocks of all in-print materials are maintained to fill orders and distribute to the staff.

Distribution of maps and publications in FY90 compared to FY89

	FY90	FY89
ISGS publications	25,743	24,654
ISGS maps	5,773	2,640
ISGS blueline maps	3,218	3,860
USGS maps	27,993	21,713

Individual orders filled for FY90 numbered 5,498. Postage meter use totalled $21,665 for 46,663 pieces.

Duplicating Services

The Duplicating Shop is able to reproduce all of the ISGS materials except four-color and oversize items. The binding produced by the new Bourg Perfect Binder has been popular and is being used for nearly all of the Survey's publications. A new vacuum feed for the Baum Folder allows folding a greater variety of paper. This past year, the duplicating shop made 1,805,391 impressions.

PUBLIC LIAISON

While public liaison activities are carried on by every staff member of the Illinois State Geological Survey, on a daily basis a formal program of interacting with the media and various government entities and constituencies of the ISGS is coordinated on a daily basis by its Public Liaison Officer. To promote broader coverage of the Survey's activities, the unit provided in-depth information to the Illinois delegation in Washington, D.C., the Illinois General Assembly, the Department of Energy and Natural Resources (ENR), the Governor's subcabinets, the Nature of Illinois Foundation, news media, governmental officials, target groups and the public. News was disseminated through the second mini-annual report; press releases; articles for magazines, newsletters and journals; personal visits and letters; reports; brochures; flyers; fact sheets; meetings for special interest groups; and exhibits.

Besides informing the public and decision makers about the Survey's research and service programs and significant events, the unit of one has responsibilities for portions of governmental relations and selected strategic planning activities. Efforts were stepped up to apprise governmental officials at all levels of the Survey's work. The need for this form of information and technology transfer has been reinforced by funding constraints on all sectors of government and the urgency to make prudent and safer use of the land available for resource and economic development. More regional planning, involving wise, environmentally-sound decisions about siting new facilities or managing natural resources, places the ISGS, with its geological knowledge and expertise as well as its databases, in a position to assist in vital decision-making processes.

To this end, the Public Liaison Officer is reaching out to municipal, county and regional planners, engineers, zoning officials, governmental board members, grassroots officials and community leaders, as well as legislators and their staff, and other departments of state government to increase the awareness of the Survey's research and service projects. Visits were made to these constituents and the media in south central, central, western, north central, northwestern and northeastern Illinois, delivering packets of information describing major projects and service programs.

New exhibits, including a 10-foot display focusing on resource identification, environmental management and economic development functions and a six-foot tabletop treatment of possible cultural and geological features, were developed to illustrate the research and service activities of the ISGS as well as the importance of regional planning and identification of natural resources for their management and developmental purposes. These displays have been used with county officials, community leaders and laymen to explain the need for geology in making land-use decisions. The Public Liaison Officer organized displays for nine meetings and planned and hosted a comprehensive exhibit of the ISGS' work at the International Geological Congress, July 1989; the Illinois Science Teachers' Conference, November 1989; two three-day meetings of County Officials, November 1989 and April 1990; and an exhibit of enhanced oil recovery research activities for the American Association of Petroleum Geologists, June 1990.

In addition, articles were prepared for The Nature of Illinois Foundation's magazine; the American Association of State Geologists' newsletter; ENR's "Illinois Resources" newsletter; ENR's "Illinois Energy Data Review" newsletter; "Illinois Energy" newsletter; and ENR's annual report. Besides teaming media with scientists working on specific issues, the unit arranged interviews for special video productions and news features taped by the electronic media. Working with the Survey's scientists, the unit prepared press releases on personnel changes, awards or special recognition, geological science field trips, the enhanced oil recovery program, a pilot project on rural wells, mine subsidence publications, poster sessions presented at the Geological Society of America, announcement of the Illinois Geologic Mapping Advisory Committee, criteria for a low-level waste site, and impact of pesticides on groundwater in Illinois. While the unit generated announcements and press releases to market new publications, their distribution was enhanced by the creation of new or the updating of selected mailing lists containing more than 3,000 addresses.

PUBLICATIONS, GRAPHICS, AND PHOTOGRAPHY

Publication Highlights During 1989-90, publication output (tables 1 and 2) held strong as the Publications team tackled a major ISGS project—editing 1,100 pages of text and producing 614 illustrations for the *Interior Cratonic Basins*, part of the World Petroleum Basin series to be published by the American Association of Petroleum Geologists. Producing the *Basins* was equivalent to turning out 11 100-page reports, each with 56 illustrations.

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(A) Librarian Pat Wasson enters data into the ISGS Library's online catalog. (B) Chief Leighton discusses artwork for the *Interior Cratonic Basins* (to be published by the American Association of Petroleum Geologists) with the art director for the project, Sandra Stecyk. (C) Jerry Glogowski, Branch Chief of Technical and Administrative Services, discusses a 5-year plan with Public Liaison Office, Sue Muckensturm. (D) Dave Cooley (right) who retired this year as head of Technical Design, Operations, and Maintenance, talks over the job with his successor, Joseph Kaczanowski. (E) As Assistant to the Branch Chief of Technical and Administrative Services, Mary Peters inputs the lab-upgrade budget to be submitted to the Capital Development Board. (F) Debra Griest, Business and Finance Manager, puts final touches on the Survey's FY92 general budget request.

F

The heavy workload was handled by adding two part-time contract artists and one editor to the core staff of one full-time and two half-time editors, three full-time artists, one typographer, one photographer, and the coordinator. Large, critical projects, such as the *Basins*, were assigned to teams of three artists and five editors to cut production time and meet tight schedules.

Outreach Large, in-depth exhibits—some with three-dimensional items—challenged the artists. Multiple board exhibits, "The Geology of Interior Cartonic Sag Basins" and "Tectonic History of the Illinois Basin," were well received at the AAPG meeting held in San Francisco in June 1990. "Biodiversity of Illinois," six panels of art and artifacts, owed much to the creativity and skills of an ISGS artist. This display was set up for public viewing in Springfield, Decatur, and Champaign, and is scheduled for Chicago soon. Another successful display used hands-on features: "County Needs and State Issues," designed for a May 1990 meeting, showed county officials how geological planning works for them. The Public Liaison Officer has used this demonstration/display for several public events. Also, the display, "Tectonic Subsidence History of the Illinois Basin," presented at the Annual Meeting of the Eastern Section of the AAPG at Bloomington, Indiana, in September 1989 won the top award.

Overall, Publications staff created graphics, edited copy, and assembled 25 posters and displays. The ISGS commitment to public information has been supported by steady output of reports, educational booklets, two issues of *ISGS Geonews*, and several brochures—including the handsome four-color flier, "Supporting the Search for Oil and Gas in Illinois."

Startup Publications staff initiated the move to replace hand drafting or scribing of some complex, color maps with computer production of negatives for four-color process printing. The Groundwater Protection program supplied the first map, *Potential for Aquifer Recharge in Illinois.* A Pubs cartographer and a geologist collaborated on the product design (composition of map and text components, color codes, line weights), which the geologist digitally formatted for conversion (via tape) to the Scitex—equipment available through an outside vendor. Although the procedure needs refining, it's cost effective.

Table 1. Final Projects*

	1986-87	*1987-88*	*1988-89*	*1989-90*
Circulars	4	3	2	1
Environmental Geology series	6	9	3	3
Illinois Mineral series	2	3	2	2
Illinois Petroleum series	0	3	2	1
Illinois Mine Subsidence Research (limited series)-	5	1	0	
Illinois Basin Consortium (new series)	-	-	-	1
Educational Extension Field Trip Guides	2	6	4	4
Reprints of outside publications	16	22	18	17
Contract/Grant Reports	3	1	2	5
Cooperative Groundwater Reports	0	0	2	1
Illinois Scientific Survey Joint Reports	0	0	0	2
Papers, articles, published speeches	24	36	22	15
Plates (>8 1/2 by 11 inch)	3	3	3	0
Brochures, fliers, announcements of pubs	13	19	15	14
Posters and displays	30	46	24	25
Special and administrative**	16	20	9	3
Geonews	3	3	3	2

*tally of projects only (published or unpublished), with no accounting for size and complexity.

**including *Interior Cratonic Basins* project: 1,100 pages and 614 figures—equivalent to production of eleven 100-page reports, each with 56 illustrations.

Table 2. Graphics*

	1987-88	*1988-89*	*1989-90*
Assorted maps, cross sections, graphs, layouts	1,321	951	556
Graphics for ISGS publications, including SSC	439	500	537
Graphics for *Basins* volume and poster			650
Totals	*2,314*	*1,451*	*1,743*
***Typographics** (number of typeset pages)*			
Text, slides, tables, forms, charts, ads	1,950	2,700	2,600
Photographics			
Photos taken for staff	1,387	6,336	4,800
2 x 2 inch slides: color	5,562	2,600	3,100
duplicates	3,105	3,200	2,900
Internegatives	-	300	480
Negatives, total	-	179	300
fineline	-	65	120
high-contrast	-	85	150
screened	-	29	30
PMT prints developed for staff, total	6,038	4,835	5,430
screened	583	270	210
reversal and acetate	-	165	120
line (not split out before)	-	4,400	5,100
Prints made, total	5,469	5,450	5,250

* artists design, create layouts, and paste up publications; they do not only draft/draw.

ISGS publications for July 1, 1989, through June 30, 1990, include the following:

Circular series—reports of significant discoveries or advances in general geology or related research, stratigraphy, or topical areas not covered in the other series.

C 545 *Study of Sulfur Behavior and Removal During Thermal Desulfurization of Illinois Coals.* 1990. K. C. Hackley, R. R. Frost, C.-L. Liu, S. J. Hawk, and D. D. Coleman. 33 pages, 22 tables, 24 figures (final preparation).

C 546 *Geological and Hydrological Factors for Siting Hazardous or Low-Level Radioactive Waste Disposal Facilities.* 1989. R. C. Berg, H. A. Wehrmann (ISWS), and J. M. Shafer (ISWS). 61 pages, 10 tables, 17 figures.

Environmental Geology series—reports of significant discoveries or advances in basic and applied environmental geological research.

EGN 131 *Lake Michigan Bibliography. Volume I: 1960-1976.* 1989. N. P. Holm and B. M. Morgan. 453 pages.

EGN 132 *Lake Michigan Bibliography. Volume II: 1977-1986.* 1989. N. P. Holm and B. M. Morgan. 531 pages.

EGN 133 *Seismicity of Illinois.* 1989. P. C. Heigold and T. H. Larson. 20 pages, 1 table, 11 figures.

Illinois Minerals series—reports of significant advances in basic and applied research in the area of mineral resources or economics.

IMN 101 *Illinois Mineral Industry in 1987 and Review of Preliminary Mineral Production Data for 1988.* 1988. I. E. Samson and S. B. Bhagwat. 45 pages, 25 tables, 12 figures.

IMN 102 *Proceedings of the 23rd Forum on the Geology of Industrial Minerals.* 1989. R. E. Hughes and J. C. Bradbury, editors. 105 pages, 15 tables, 101 figures (released).

IMN 103 *Directory of Illinois Mineral Producers, 1988-1989.* I. E. Samson and J. M. Masters. 134 pages, 2 tables, 3 figures.

Illinois Petroleum series—reports of significant discoveries or advances in basic or applied research in the area of oil and gas resources.

IP 133 *A Gravity Survey of Marine Field: Case Study for Silurian Reef Exploration.* P. C. Heigold and S. T. Whitaker. 19 pages, 10 figures.

Cooperative Groundwater Report series—cooperative research involving the Illinois State Geological and State Water Surveys.

Coop 12 *An Initial Evaluation of the Impact of Pesticides on Groundwater in Illinois: Report to the Illinois Legislature.* 1990. D. P. McKenna, T. J. Bicki, W. S. Dey, D. A. Keefer, S. V. Panno, C. Ray (ISWS), S. D. Wilson (ISWS), S. C. Schock (ISWS), and E. Mehnert. 106 pages, 16 tables, 22 figures.

Illinois Scientific Surveys Joint Report series—intersurvey reports on multidisciplinary studies.

ISSJR 2 *Evaluation of Underground Injection of Industrial Waste in Illinois.* 1989. R. D. Brower, A. P. Visocky (ISWS), I. G. Krapac, B. R. Hensel, G. R. Peyton (ISWS), J. S. Nealon (ISWS), and M. Guthrie (Engineering Science Inc., Atlanta). 150 pages, 12 tables, 34 figures.

Contract/Grant Report series

C/G 1989-2 *Geophysical Exploration for Potential Groundwater Resources Near Bloomington, Illinois.* 1989. T. H. Larson and V. L. Poole. 51 pages, 1 table, 12 figures.

C/G 1989-3 *Shallow Groundwater Resources of Kane County.* 1989. P. R. Seaber, B. Brandon Curry, S. S. McFadden, R. H. Gilkeson, and A. P. Visocky (ISWS). 38 pages, 7 tables, 15 figures (replaced by C/G 1990-1).

C/G 1990-1 *Hydrogeology of Shallow Groundwater Resources, Kane County, Illinois.* 1990. B. B. Curry and P. R. Seaber. 37 pages, 2 tables, 15 figures, 1 plate.

U.S. EPA report *Batch-Type Procedures for Estimating Soil Adsorption of Chemicals.* 1990. W. R. Roy, I. G. Krapac, S.F.J. Chou, and R. A. Griffin. 97 pages, 20 tables, 48 figures (scheduled to be printed by U.S. EPA).

ENR report *Persistence and Mobility of Selected Pesticides in Loessial Soils of Illinois.* 1989. D. P. McKenna, T. J. Bicki (University of Illinois), W. S. Dey, W. R. Roy, M. V. Miller, D. D. Coleman, S.F.J. Chou, and J. Valkenburg. 91 pages, 48 tables, 12 figures.

Educational Series—designed for all levels of education and experience.

ES 13 *Guide to Pennsylvanian Fossil Plants of Illinois.* 1990. J. Jennings. 90 pages, 48 illustrations.

Illinois Basin Consortium series

IBS 1 *Geology of the Lower Pennsylvanian in Kentucky, Indiana, and Illinois.* 1989. J. C. Cobb, coordinator, Kentucky Geological Survey: Kentucky, Indiana, and Illinois Geological Surveys. 108 pages. (ISGS Publications staff edited and illustrated three chapters

Educational Extension Geological Field Trip booklets

1989-C *Woodstock Area.* October 1988. J. M. Masters and D. L. Reinertsen.

1989-D *Mt. Vernon Area, Jefferson County.* November 1989. D. L. Reinertsen, S. T. Whitaker, and L. R. Follmer.

1990-A *Ferne Clyffe Area, Johnson, Pope, Saline, and Union Counties.* April 1989. J. A. Devera, S. T. Whitaker, and D. L. Reinertsen.

1990-B *Joliet Area, Cook, Grundy, and Will Counties.* May 1990. D. L. Reinertsen and L. R. Smith.

Guidebook series—discussions of geology, stratigraphy, structure, and other natural features that are the focus of major field trips.

G 20 *Quaternary Records of Central and Northern Illinois.* L. R. Follmer, D. P. McKenna, and J. E. King (Illinois State Museum). 86 pages (AMQUA guidebook reissued as an ISGS Guidebook).

G 23 *Wisconsinan and Sangamonian Type Sections of Central Illinois.* E. D. McKay, D. P. McKenna, and J. E. King. (AMQUA guidebook reissued as an ISGS Guidebook)

Reprints of papers published in journals or proceedings

1989 1989D, *Froth Flotation of Coal Fines in Illinois Coal Mine Effluent*, L. A. Khan, J. W. Baxter, and R. J. Rice • 1989E, *Recovery of Coal from Effluent of Two Operating Mines*, L. A. Khan, J. W. Baxter, and R. J. Rice • 1989F, *Economics and Environmental Costs/Benefits of Secondary Fine Coal Recovery: An Illinois Case Study*, S. B. Bhagwat, L. A. Khan, L. M. Curran, J. W. Baxter, and R. J. Rice • 1989G, *Source and Origin of Roxana Silt and Middle Wisconsinan Midcontinent Glacial Activity*, W. H. Johnson and L. R. Follmer • 1989H, *Loessial Soils: Their Relationship to Width of the Source Valley in Illinois*, B. R. Putman, I. J. Jansen, and L. R. Follmer • 1989I, *Age, Stratigraphic Position, and Significance of the Lemont Drift, Northeastern Illinois* • 1989J, *A Regional Three-Dimensional Map of Laurentide Glacial Sediments in the United States: Overview and Applications for Hydrogeology and Land Use*, D. R. Soller • 1989K, *Hydrogeological Applications to Regional Three-Dimensional Lithostratigraphic Mapping*, J. P. Kempton, R. C. Berg, and D. R. Soller • 1989M, *Improving the Floatability and Cleanability of Ultrafine Coal by the Use of Anionic Surfactants*, R. R. Read, C. Y. Meyers, L. R. Camp, and M. Summers • 1989N, *Use of Geophysical Logs to Estimate Water Quality of Basal Pennsylvanian Sandstone, Southwestern Illinois*, by V. L. Poole, K. Cartwright, and D. Leap • 1989O, *Excavation of an Instrumental Earthen Liner: Inspection of Dyed Flow Paths and Morphology*, K. A. Albrecht, B. L. Herzog, L. R. Follmer, I. G. Krapac, R. A. Griffin, and K. Cartwright • 1989P, *Absence of Altonian Glaciation in Illinois*, B. B. Curry • 1989Q, *Clast Poughing, Lodgement and Glacier Sliding Over a Soft Glacier Bed*, P. U. Clark and A. K. Hansel

1990 1990A, *Sidescan Sonar Examination of Deteriorated Revetments and Bulkheads Along Chicago's Lake Front*, M. J. Chrzastowski • 1990B, *Multiple Wisconsinan Glacigenic Sequences at Wedron, Illinois*, W. H. Johnson and A. K. Hansel • 1990C, *Comparison of Slug Test Methodologies for Determination of Hydraulic Conductivity in Fine-Grained Sediments*, B. L. Herzog and W. J. Morse

Special publications

AAPG *Interior Cratonic Basins.* 1990. M. W. Leighton, D. R. Kolata, D. F. Oltz, and J. J. Eidel [editors]. World Petroleum Basins, American Association of Petroleum Geologists. Manuscript submitted to AAPG: 1,100 pages text, 614 illustrations.

Geonews Summer 1989, Summer 1990

Annuals Two reports • *Illinois State Geological Survey Annual Report, July 1988 -June 1989.* 176 pages. • *ISGS 1988-89, Science Focusing on Issues and Trends, Future Needs.* 31 pages.

Catalog Geological Samples Library

Posters, displays for Goodwin (SISS), Follmer, Moore, J. Treworgy (2), Whitaker (2), Heigold, Seyler, Morgan/Kempton, Harvey, Poole, Herzog, Muckensturm (2), Bang, Berg, Hansel, McKay/Killey, Larson, Kolata (2), Leighton, J. Frost, Masters, and P. Reed

Brochures	Biodiversity brochure, IMSRP update, 1989 field trips, two coal bank brochures, CO/ethanol method update, desulfurization update, oil and gas section four-color flier
Map	*Potential for Aquifer Recharge in Illinois (Appropriate Recharge Areas).* D. A. Keefer and R. C. Berg (in preparation).

TECHNICAL DESIGN, OPERATIONS, AND MAINTENANCE

The Technical Design, Operations, and Maintenance Shop provides the ISGS with special services that would otherwise have to be handled through contractual services of the University of Illinois or outside vendors. Staff members install and maintain the air conditioners; repair, install, maintain and move office/laboratory furniture and equipment; and otherwise care for many parts of the Survey's laboratories and offices. In addition, they are responsible for the upkeep and maintenance of the Shop and Equipment and the Clay Hydrogeology Liner buildings. Extra effort is made to provide safe and efficient work areas and to install, repair, and maintain laboratory and office equipment in a timely fashion.

Custom fabrication and repair of laboratory, field and scientific apparatus as well as office furniture are specialties of the shop. For example, its personnel furnished custom-made computer workstation-desks to the Business and Financial Services Unit. This type of project required metal working, woodworking and electrical hook-ups, involving the entire staff.

Some 335 internal work orders were completed, an increase of 20 over the previous reporting period, requiring repairs, fabrication, moving, maintenance and other services. Many other jobs were performed in response to verbal requests, notes, and regular maintenance procedures that are interspersed with the more involved shop projects.

David B. Cooley, Supervisor and Principle Technician, retired December 1, 1989, after more than 35 years of service. Joseph S. Kaczanowski, Instrument Specialist in the shop 14 years, assumed the duties of Technician and Supervisor of the unit.

Drill Rig

Now fully operational, the ISGS drill rig, under the jurisdiction of the unit, was employed on three ISGS projects last year. New 3.25-inch and 4.25-inch hollow-stem drill augers coupled with the operator's extensive improvements to the drill rig have readied the equipment for field activities.

Last year, Timothy Young, the Drill Rig Operator, received his bachelor's degree in physical and human geography from the University of Illinois, completed the Acker Diamond Drill Operators training program, and attended a 3-day seminar on environmental drilling technology at the University of Wisconsin.

Electronics Shop

The Electronics Shop provides support in electrical and electronic repairs, maintenance and installation throughout the ISGS. This past year, 170 internal work orders were processed, 12 more than handled in the previous reporting period.

Responsibilities of the staff include maintaining and repairing the telephone hardware and wiring within the Survey's offices as well as maintaining and repairing electrical systems involved with ventilation and air conditioning systems. Fabricating cables and interconnects for the ethernet network system is also an ongoing task.

Of special value to the ISGS is the staff's ability to repair field equipment for rapid turnaround to field use and to maintain old equipment for research purposes. These services save the Survey thousands of dollars each year, while providing invaluable services to support scientific research.

Automotive Section

Servicing and keeping records on the Geological Survey's fleet of 25 vehicles and the Illinois Natural History Survey's fleet of 48 vehicles is the responsibility of the automotive staff members. Assuring the readiness of automotive and special-purpose vehicles is important to the performance of business and field activities at both Surveys. Vehicle record keeping has been computerized by the staff, freeing more than 20 hours a month for other tasks.

The ISGS requisitioned seven new vehicles last year, boosting its fleet by two vehicles. One special-purpose one-ton van replaced an aging carryall and was outfitted with new down-hole logging equipment. The remaining new vehicles replaced those driven more than 100,000 miles and a 21-year-old pick-up truck.

The staff directed a special equipment add-on to vehicle 19, a one-ton, dual-wheel, crew-cab pick-up truck, and the installation of a new Giddings sampling drill rig.

Chris R. Wilson, the Vehicle Maintenance Technician 11 years, was promoted, assuming craftsman duties in the Technical Design Shop while acting as Vehicle Coordinator and coordinating the work of Steve A. Wildman, who was hired as Vehicle Maintenance Technician.

Applied Research Laboratory Shop

A total of more than 125 repairs, fabrications, moving, maintenance, and other jobs were completed for internal work orders during the period. In addition to the contract projects, the staff maintained and repaired the laboratory's equipment.

EDUCATIONAL EXTENSION

The Educational Extension Unit provides information and materials on the state's geology, mineral resources, and landscape to elementary, high school, and college teachers, students, and the general public. The staff also presents slide-illustrated talks about the Survey's research and service activities to teachers' workshops, high school science classes and science clubs, and citizens groups throughout the state.

Geological science field trips Although designed to furnish teachers with background materials for classroom use, the four field trips held each year are popular events for the public as well. A guide leaflet is furnished to the participants. Additional guide leaflets from more than 80 previous field trips are maintained on permanent file to allow teachers and others to obtain them for future reference. During the year, the unit hosted field trips to the Woodstock area, October 14, 1989; Mt. Vernon, November 4, 1989; Ferne Clyffe State Park, April 20, 1990; and Joliet, May 12, 1990. Of the 535 attendees, 163 were elementary, high school, and college students; 86, elementary, secondary, and college teachers; and 286 others.

The trip to Ferne Clyffe, which emphasized recent studies of trace fossils in Lower Pennsylvanian rocks, was designed to show the public how the ISGS' geologists are using data from trace fossils and detailed geological mapping to reinterpret the depositional environments of sedimentary rocks in the region. As part of this observance of Earth Day 1990, staff members from the Natural History Survey joined the field trip to identify flora and fauna and describe the ecology of the area for participants. A preview of this trip was held the preceding day, April 19, for 10 teachers in the area involved in an in-service training day. On the field trip to the Mt. Vernon area, a geologist from the Oil and Gas Section described problems oil well operators encounter extracting oil from reservoirs and the research now under way at the Survey to increase the amount of oil recovered from existing fields through better characterization of the geology of the reservoirs' rocks.

Teachers' workshops During the reporting period, the unit and others from the Survey's staff participated in several workshops for teachers. The unit presented the slide-illustrated lecture "Introduction to the Geology and Occurrence of Illinois' Coals" for workshops on energy offered by

Energy Education Associates in Pittsfield on July 25, 1989, and in Oakbrook Terrace, August 15. On March 3, 1990, the unit prepared a table of educational materials available from the Survey for a Peoria-area teachers' workshop held at Wildlife Prairie Park. With assistance from science teachers from the Urbana schools, a workshop on "satellite image maps for the classroom" was offered during the Illinois Science Teachers Association's annual meeting at Parkland College, November 3, 1989.

Displays A major display, "ISGS Maps the Future of Illinois," was exhibited at the International Geological Congress in Washington, D.C., July 9 to 13, 1989. Another exhibit, comprised of materials from the three Scientific Surveys on the "Biodiversity in Illinois," was completed during the fall and presented in the main offices of the Marine Bank in Springfield during October and in the bank's Champaign branch in November. That display was hosted during the spring by the First National Bank, Decatur. The staff of the Society for the Illinois Scientific Surveys made arrangements for these locations and extended invitations to the local school districts to bring students to visit the display. For the weekend of Earth Day 1990, the biodiversity display was placed at Market Place Mall in Champaign and staffed continuously by volunteers from the three Surveys to answer questions from the public.

Other Activities Color slides from the Educational Extension Unit's extensive collection have been used by several staff members from other sections for publication and talks. The head of this unit continues to attend meetings of the Statewide Advisory Board on Conservation Education of the Illinois State Board of Education and is one of the Survey's representatives on the Groundwater Protection Education Subcommittee.

GEOLOGICAL RECORDS AND SAMPLES LIBRARY

As a result of the continued downturn in the oil and gas industry, the overall volume of oil and gas data handled by Geological Records decreased slightly in 1989-90 (see table). The downturn in petroleum industry records was partially offset by three significant contributions of oil well logs and continued revitalized efforts to obtain and enter water well records into the system.

The number of oil and water well samples processed by the Geological Samples Library also increased during 1989-90.

Geological Records Unit

The Geological Records Unit (GRU) is the repository for drilling records in Illinois, including oil and gas wells, water wells, engineering borings, and miscellaneous test holes. This database has long been of value to the oil industry, coal industry, hydrogeologists, engineers, land-use planners, academic institutions, land owners, general public, and staff.

The Illinois Department of Mines and Minerals (IDMM) instituted new operating procedures on February 1, 1990, regarding well site and well records violations. It now requires a list of non-compliant operators quarterly. Geological Records, in cooperation with the ISGS Computer Research and Service Section, is providing this list in a computerized format. As a result of changes, the quantity of material required from the noncompliant list has decreased since March, 1990.

The total number of pieces of mail decreased (872 less than FY89). The decrease was in part offset by submittal of large collections of logs donated to the Survey by the Hydro-Carbon Survey, the Ohio Geological Survey, and an independent operator.

Improvements to the unit were made as part of the "Geological Records upgrade". Eleven new file cabinets were added to the main collection to house additional file folders. Two new air conditioners were purchased and installed in the main room. A new copier to copy single sheets was also purchased. These items add to the efficiency of the Unit and were purchased by Build Illinois Funds.

The Geological Records staff assists visitors and the ISGS scientists with requests for information regarding drill-hole records on file. Use of the facility decreased by 219 visitor days during the reporting period. Geological Records completed a six-week audit of staff use of the records facility between

January 15, 1990, and February 28, 1990. During this period, 241 staff members used the records facilities on 341 occasions. Orders totaling 2,501 were processed, an increase of 782.

Annual Statistics of the Geological Records Unit

Data Acquisition		
Basic Data	*1988-89*	*1989-90*
Oil Permits	1,196	1,280
Water Permits	14,689	8,343
Water Task Force Records	12,486	19,836
Plugging Affidavits - oil	1,727	1,191
- water	2,662	2,160
Logs		
Electric Logs	824	1,211
Micro Logs	247	215
Radioactivity Logs	1,424	1,417
Miscellaneous geophysical logs	83	134
Total geophysical logs	2,578	2,977
Drillers logs	219	149
Drilling time logs	368	254
Company sample and core studies	64	68
Geologic tops	155	202
General data (completion data)	1,730	1,270
Water well and test hole logs	8,928	7,510
Miscellaneous	92	832
Total new logs received	14,134	13,262
Cumulative Totals		**Cumulative to**
Collections	**FY90**	**June 30, 1990**
Processed drill hole records	23,525	310,430
Books of processed drill-hole records	20	856
Skeleton logs (records prior to 1920)		17,920
Books of skeleton logs		40
Books of confidential logs		15
Books of out-of-state logs		14
Books of misc drill-hole records		9
Geophysical logs	2,977	127,222
Coal pluggings	620	21,157
Service Activities	**1988-89**	**1989-90**
Visitor days	1,204	985
Files used by public and staff	64,334	44,421
Phone calls	3,344	3,345
Total orders processed	1,719	2,501

Water Well Records Task Force Effective November 1, 1988, a Task Force was formed to sort, organize, and enter into the computer database information from some 25,834 water wells. The Task Force, using the CONQuEST data entry program developed by the Survey's Well Database Unit, completed this project during March 1990 by entering 13,348 records. This important milestone was scheduled for completion during June, 1990. Currently, the Task force is entering data from an additional

22,300 water well logs that had been temporarily stored in 31 well log books. Geological information from these records is being entered into the system, and summary sheets are being produced and added to the main file collection. Some 6,488 records from this collection have been added by the Task Force as part of the 19,386 records entered this year

Data Acquisition Oil well permits issued (1,280) by the Illinois Department of Mines and Minerals increased by 84 from last year's 1,196. Oil and water well plugging affidavits decreased during the reporting period. Of the 3,351 affidavits received, 1,191 were for oil wells (compared to 1,727 for oil the previous year) and 2,160 for water wells (compared to 2,662 the previous year). Total new logs received (18,399) increased by 30 percent. The following table summarizes the GRU's activity.

Geological Samples Library

The ISGS Geological Samples Library manages one of the largest physical collections of geological samples in the United States. Its staff receives, processes for storage, and archives these important collections, as mandated by Illinois Statute (chapter 96, Natural Resources Conservation of Oil and Gas). The Geological ISGS began collecting these samples in the early 1900s when the USGS provided a series of drill cuttings to the State Geologist. Today, this unique repository houses cores and cuttings that represent billions of dollars invested in Illinois by petroleum and mining and engineering companies. The collection attracts users from across the country, encouraging potential investment in Illinois by both in-state and out-of-state companies and providing a database to address environmental and resource issues.

Visitors and staff referred to our files 270 times (29 more than in FY89) and studied 560 sets of samples or core (27 less than FY89). Visitors to the Annex facility represent a wide range of geologic interests. Independent consultants and representatives of major oil companies, universities, and government agencies are typical visitors to the Samples Library. Of the 138 (two less than FY89) visitors to the Samples Library, 41 percent were from out of state. The decline in visitors reflects the continued decrease in oil exploration.

GSL staff assemble rock and mineral kits for distribution to schools. A 35-specimen set familiarizes teachers and students with rocks, minerals, and fossils of Illinois. In the past year, 92 specimen kits (130 less than the previous year) and 24 orders were filled for the reconditioning of sets already distributed to schools.

Acquisition of Cuttings Samples Oil and water well cuttings added to the Geological Samples Library during the reporting period increased the total footage of cuttings to 741,954,678 feet. During FY90, the permanent file of the Samples Library acquired 234 sets of well sample cuttings, representing more than 252,291 feet of drilling. These samples are contained in 565 boxes and occupy an additional nine linear feet of storage space. Some 131 sets of well cuttings were requested from permits issued last year, compared with 161 the previous year. The Samples Library files of 66,877 sets of well cuttings are stored in 102,414 boxes and utilize 1,427 linear feet in a 3,780-square-foot area of the Samples Library.

Samples from an additional 218 oil and water wells (37 more than the previous year) await processing. At present, the interval between receipt and permanent processing is 12 months, a two-month increase over last year. Additions to the permanent files consisted of 75 washed oil-test sets from rotary drill wells and 159 water wells. Of the 131 oil well cuttings requested, 62 percent were received last year.

Acquisition of Core Samples Rock cores from oil and mineral borings that were added to the Geological Samples Library during the reporting period increased the total footage of core to 982,371 feet. During the reporting period, 60 cores, selected from boreholes representing an initial 44,480 feet of drilling, were collected, examined, and processed into the permanent files. This year's additions are housed in 1,780 cardboard core boxes assembled by the staff. These cores represent a significant addition to the core collection. The entire collection of 13,483 sets of core on permanent file is stored on steel racks in an area covering approximately 4,300 square feet of the Samples Library.

Other Sample Collections In cooperation with the Industrial Minerals Section, an additional 2,796 samples were split and prepared for insoluble residues. The ISGS staff generates a large volume of research material. The GSL staff also received, sorted, and filed collections from Survey staff. These staff samples are located in the Staff Research Collections storage area of the Samples Library. Some 1,476 items, mostly analytical samples were added, bringing the total to more than 36,476 research samples on file at the Annex. Another 9,156 feet of core was received, processed, and temporarily stored as part of ISGS research projects.

The ISGS provides sample bags for the collection of well sample cuttings requested on permits issued by the state. During the past reporting period, the Samples Library supplied drillers and operators with 17,250 sample bags for requested well cuttings (7,750 less than the previous year).

CAPITAL PROJECTS

Previous Projects Three Capital Development Board (CDB) projects, begun in FY87, have been completed:

Description	Fund	Cost
Renovation of the Natural Resources Building, the Natural Resources Annex, and the Applied Research Building to upgrade laboratory facilities: 244-030-003	CDB	$470,000
Renovation of the Natural Resources Building and Studies Annex and Applied Research Building to upgrade laboratory facilities: 244-030-003	CDB	$316,000
Installation of a fire/smoke alarm system in the Natural Resources Building: 244-030-004	CDB	$308,000

Work consisted of the following:

- replaced chemical fume hoods and relocated motors and fans to the roof or attic so that fume vents have negative internal pressure through most of their run from workspace to exit vent;
- relocated or installed shower drench stations;
- installed eye-face wash stations;
- replaced laboratory benches and sinks that had corroded plumbing, unsafe and inadequate electrical service, corroded and porous work surfaces, inadequate or unsafe utility service; replaced and improved utilities;
- installed wall cabinets to provide enclosed storage of reagents and glassware, especially where inadequate shelving and other storage space for essential laboratory equipment had resulted in workspace being used for storage;
- replaced old incandescent lights with fluorescent lights to help keep laboratories cool, to avoid the possibility of igniting explosive gases in the event of lamp globe breakage, and to increase the brightness of illumination in the laboratories;
- repainted the laboratories with light colors to further increase the apparent brightness of room illumination, after removing and rehabilitating peeling paint, and cleaning 35- to 45-years of accumulated grime and dust from the walls, ducts, and pipes;
- installed a make-up air system;
- removed asbestos; installed fire/smoke alarm system for the Natural Resources Building.

Laboratories in two buildings that were included in the work are as follows:

Natural Resources Building

Room Number	Lab Name
318A&B	Volatile Storage Room (acid & salt)
323	Spectrochemical Preparation
325	Atomic Absorption Lab
326	Radiochemistry Lab
329	Rock Analysis
335	Microbial Geochemistry
363	Organic/Analytical/Storage
365	Organic Geochemistry
369	Organic Geochemistry
371	Organic Geochemistry
20	Isotope Chemistry
226	Coal Paleobotany
302	Isotope Geochemistry
311	Oil and Gas Analysis Lab
313	Optical Emission Lab
324	Microbial Geochemistry
331	Furnace Room
338	Clay Mineralogy Lab
Annex	
102B&C	Paleontology Lab
202	Environmental Geology

FY91 Capital Projects An approved FY91 capital project will continue the Natural Resources Building Laboratory Upgrade at a cost of $630,000. The FY91 upgrade will include the following laboratories:

Natural Resources Building

Room Number	Lab Name
5	Engineering Geology
20	Isotope Geochemistry
22	Core Laboratory
26	Rock Grinding
31	Industrial Minerals
33	Industrial Minerals
207	Mining Geology
217	Coal Petrography
223	Low Temperature Ashing
301	Petrography
302	Isotope Geochemistry
311	Oil and Gas
325	X-Ray Fluorescence
331	Furnace Room
335	Microbial Geochemistry
364	Mass Spectrometer
403	Photo Lab
425A	Groundwater Lab
425B	Groundwater Lab
435	Groundwater Lab

This project is on target for completion during the summer of 1991.

Honors

HONORS AND AWARDS

Prizes, Medals, High Offices, and Other Honors

Robert A. Bauer and Beverly L. Herzog were co-recipients of the ISGS Distinguished Achievement Award on October 24, 1989. In presenting the award to Robert Bauer, the Chief cited the national and international recognition he received for his research on the applications of geology to tunneling and mine subsidence and his major contributions to the success of the Geological Survey's programs of geotechnical studies for the site proposal for the SSC and the Illinois Mine Subsidence Research Program. In presenting the award to Beverly Herzog, the Chief noted the national recognition she received for her studies of groundwater geology applied to groundwater monitoring, her being credentialed as 1 of only 250 Certified Groundwater Professionals, her being named an Outstanding Young Woman of America by the Outstanding Americans organization, and her achievements as acting head of the Groundwater Resources Section during the prolonged illness and convalescence of **Paul R. Seaber**.

Keros Cartwright was awarded a Certificate of Leadership by the International Biographical Centre, Cambridge, England.

William G. Dixon, Jr., was awarded a Certificate of Appreciation by the Association of Engineering Geologists for his service as editor of *AEG News*. The award was presented at the Association's annual meeting in Vail, Colorado, October 4, 1989, by President Christopher Mathewson.

Gary B. Dreher received a citation signed by Chancellor Morton Weir, Chief Morris W. Leighton, and other officials recognizing him as an "outstanding volunteer, for his significant contributions to the Campus Charitable Fund Drive."

J. James Eidel was elected to the Foundation of the Society of Exploration Geologists.

Donald A. Keefer was elected to membership in Gamma Sigma Delta, the student honor society for agriculture.

Janis D. Treworgy, Michael L. Sargent, Dennis R. Kolata, and Sandra K. Stecyk received the Vincent E. Nelson Award for the best poster at the annual meeting of the Eastern Section of the American Association of Petroleum Geologists, September 11-13, 1989, at Bloomington, Indiana.

Alison B. Lecouris and Nicholas P. Schneider were recognized as Outstanding New Staff Members by the Illinois State Geological Survey at the Retirement and Recognition Party, October 23, 1989. The citations noted their "noteworthy contributions to our research and service programs...and their prospects for future success."

Morris W. Leighton was named as AAPG Distinguished Lecturer this past year.

E. Donald McKay, Lisa R. Smith, Robert R. Pool, Gail D. Taylor, Sally Denhart, Robert J. Krumm, and Barbara J. Stiff received First Place Awards in the categories of Most Analytic Poster and Most Communicative Poster, and Second Place Awards in the Categories of Most Attractive Poster and Most Unusual Poster for the display, "Unraveling Complex Geologic Settings Using GIS," at the Tenth Annual International ARC/INFO Users Conference in Palm Springs, California, May 14-18, 1990. The selections were made by the conference participants from among approximately 250 poster displays at the conference.

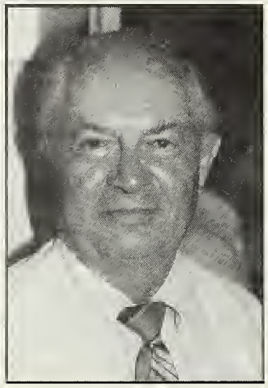
Donald F. Oltz was awarded a certificate of appreciation by the Illinois Oil and Gas Association at their annual meeting in Evansville for his work on behalf of the independent producers in the Basin.

The **Illinois Mine Subsidence Research Program** won an Environmental Achievement Award from the National Environment Awards Council. The program underwent a rigorous verification process and is listed in the 1990 Environment Success Index.

Activity Measures

A

B



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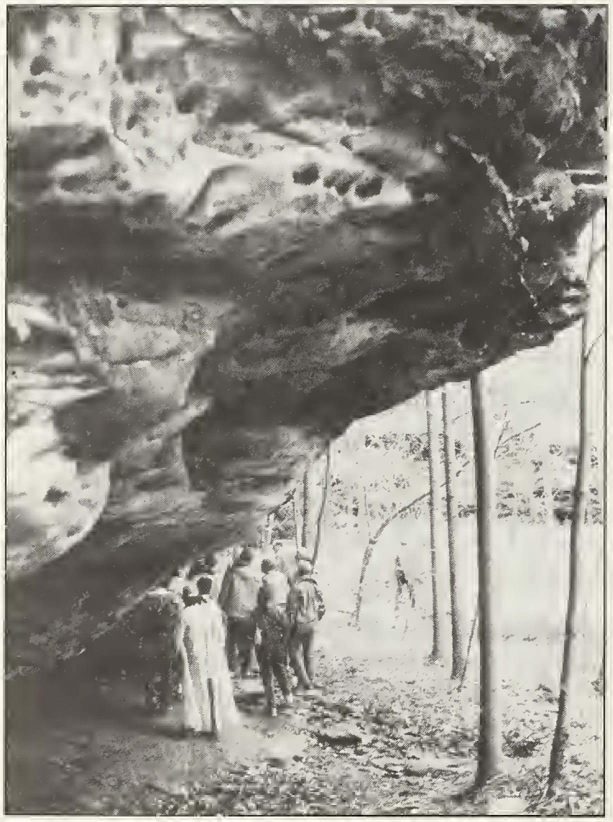

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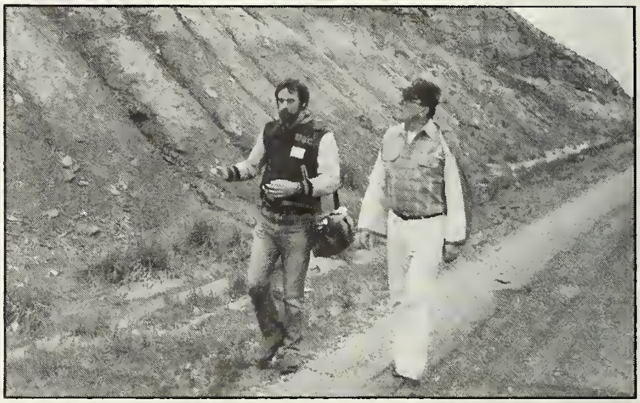

(A) Oil and Gas staff at a weekly review meeting of the ENR/DOE Improved and Enhanced Oil Recovery Project. (B) Donald Dickerson, organic chemist, retired in April after more than 36 years at the Survey. (C) High school teachers on geological science field trip to Ferne Clyffe in southern Illinois. (D) Steve Whitaker, Oil and Gas Section, and Jerry Glogowski, Branch Chief of Technical and Administrative Services, examine the Reynoldsburg Coal near Interstate 24. (E) A display of ISGS maps at the Illinois Geological Mapping Advisory Committee in Champaign, December 1989. (F) Paul DuMontelle, acting Branch Chief of Environmental Geology and Geochemistry, works with the hands-on map presentation prepared for the meeting of the Illinois Association of County Officials in Springfield. Looking on is ISGS Public Liaison Officer, Sue Muckensturm.

E

F

ACTIVITY MEASURES

All Illinois state agencies are required to provide activity measures as part of their annual budget presentations to the legislature. Selected activity measures also are included in the Governor's report on the Illinois state budget. Internally, we use a wide range of activity measures to gauge how effective we are at reaching the public with our information and services. The measures also are helpful indicators of where our research and service staff are applying their greatest energies, and to what degree we may need to adjust or reshape our program, budget, or organization. The table at the end of this section shows selected activity measures, distributed by program areas.

Some of our annual activity measures are calculated from samples taken over a period of a few months. For example, the total number of long-distance telephone calls made by our staff is calculated from the total number of calls billed to all our telephones in October 1989 and May 1990 and the numbers of telephone calls and visitors received by the Information Office are based on a two-month sample. Although inexact, we believe that the accuracy of these estimates is sufficient to gauge trends from one year to the next.

Measures

Research Activities Our scientists reported 159 state-funded research projects in progress during the year, 23 more than last year. Of these, 42 were in the Environmental Geology program, 65 in Mineral Resources and 52 in General and Basic Research. Our scientists reported that a total of 80 active sponsored research projects were in progress during the year, of which 36 were in Environmental Geology, 38 in Mineral Resources and 6 in General and Basic Research. Our scientists submitted 58 research proposals to various sponsoring agencies, about the same number as last year. Most of these proposals are submitted at the request of the sponsoring agency following discussions of their research needs with our scientists. Consequently, we enjoy about a 75 percent success rate for the proposals we submit.

To present our research information to the public and the scientific community, we published a total of 249 new articles, reports, maps, abstracts and other formally released documents in our own series and in other forums such as scientific journals, proceedings volumes, and guidebooks. This number is slightly higher than last year and continues a slow increase in the number of publications being produced. The Library/Map Room and Information Office sold 8,994 copies of our publications and 5,088 copies of our maps. The number of maps sold is more than double the number last year. We distributed 16,749 free copies of our publications and 685 free maps, slightly more than last year. The total of 31,516 copies of our publications distributed this year is about 15 percent greater than last year's total. Since we have been trying to keep our mailing lists down to help control the costs of publishing, the increased distribution probably reflects a significant increase in demand for our information and services. In addition to our own publications, we sold 22,332 copies of U.S. Geological Survey topographic map products and distributed 5,601 free copies of these products. The total of 27,993 copies of USGS products distributed is 29 percent greater than last year.

Public, Government and Industry Services

Information Responses As shown in the accompanying table, we hosted 6,643 visitors this year to provide scientific information, a decrease of 8 percent from last year. The decrease in numbers was mainly in the number reported by the Information Office; the number of visitors reported by our scientists is essentially the same as last year. To respond to inquiries and conduct the Survey's business, we sent out 2,065 letters (19 percent more than last year) and made an estimated 24,000 outgoing long-distance telephone calls (26 percent more than last year). Included in the outgoing calls were almost 1,534 facsimile transmissions of documents. The Information Office received an estimated 11,400 telephone calls (5 percent more than last year). Only 985 visitors used the Geological Records Unit during FY 1990, a decrease of 18 percent from last year. Despite this drop in visitors, we sold 4,666 copies of well logs and distributed 1,023 free copies. The number of log copies sold is 60 percent more than last year.

The Geological Samples Library hosted 138 external visitors, 2 fewer than last year, and distributed 258 sample sets to the those visitors.

Identifications, Analyses, and Reports of Results To conduct their various research and service projects during the year, ISGS chemists completed at least 23,929 separate elemental determinations on 5,795 samples of rock, soil, brine, coal, water and other materials. Our scientists also completed x-ray mineralogical determinations on 4,062 samples, despite the fact that our Scintag automatic diffractometer was out of service for almost 7 months. Other analyses included 861 elemental determinations on 145 samples using the energy dispersive x-ray analysis (EDX) system on the scanning electron microscope; 418 microscopic analyses for thin section petrography, coal petrography and palynology; 190 determinations of the acid-insoluble residue contents of carbonate rock samples; 245 hand-specimen identifications of rock types or fossils for visitors or other scientists; 3,651 determinations of the suspended sediment content of surface water samples and 338 rock strength determinations. In the field and in the laboratory, our scientists described 191 cores of surficial or bedrock materials and 95 sample sets from drill holes; measured 70 stratigraphic sections; conducted 65 electrical earth resistivity surveys and 17 seismic surveys, and geophysically logged 64 boreholes. To report the results of these analyses, and for other purposes, our scientists prepared 705 unpublished reports, six more than the number reported by the scientific program areas last year. The total number of "unpublished reports" listed in last year's table of activity measures erroneously included the total number of distributed copies of educational extension field trip guide leaflets and other brochures under the "Administrative Services" column. This number was also included in the total number of published items distributed; its inclusion in the "unpublished reports" category, therefore, was misleading. This year's unpublished reports included 87 groundwater possibility reports, 7 waste disposal site reviews, 62 high-volume well reports and 76 mine subsidence investigations. The staff of the Computer Research and Services Section and others in the ISGS wrote 931 computer programs, completed 81 data-entry tasks, digitized 422 maps and plotted 1,047 digital map files.

Continuing Scientific/Educational Contributions Geological Survey staff members presented papers at scientific meetings, made speeches or other informational presentations at public meetings, discussed posters, participated in field conferences to consider geological problems first-hand with their colleagues and otherwise transferred information to fellow scientists and the public on 727 occasions during the year, including 154 interviews with print, radio and television reporters. In addition, our scientists either taught or participated in 149 workshops, seminars or classes, including a small number presentations to elementary, high school and college classes. The specific occasions are tabulated in the "Recognition and Service" section of the Annual Report. Our scientists assisted graduate students in geology and other subjects across the entire state, nation and world on at least 259 occasions during the year. The Educational Extension Unit distributed 116 complete or partial rock and mineral sets to schools in the state, 26 coal ball slices, 18 free topographic map sets and 463 copies of various Educational Series booklets.

Public, Industry, Government Contributions Staff members of the ISGS serve on 55 advisory boards for local, state or national government agencies or other sorts of bodies. Our scientists presented oral or written testimony to various local, state or national government bodies, advisory commissions or, in some instances, the courts of law, on 143 occasions during the year. In addition, some 116 of our staff members hold elective or appointive offices in various professional societies. Through those offices, they provide services to the scientific community, industry and government, including reviewing manuscripts for journals and proposals for funding agencies, chairing technical meetings and administering the professional organizations, devising new standards for analytical methods, and publishing newsletters and summary articles that provide information about societal and industry trends.

Illinois State Geological Survey Selected Activity Measures 1989-90

	Mineral Resources	Environ. Geology	General & Basic Res.	Admin. Services	Total
Reports/Maps					
· Published	97	78	62	12	249
· Distributed					31,516
Unpublished Reports	355	332	18	--	705
Visitors and Office Conferences	1986	433	366	3885	6,670
Letter Responses	741	298	591	435	2,065
Talks, Posters Displays, Interviews	248	203	118	58	727
Workshops, Classes Seminars	43	52	32	22	149

Financial Report

FINANCIAL REPORT

Fiscal Year 1990

Appropriated Fund Of the appropriated FY90 funds totalling $6,310,800 (Tables F-1 and F-2), the Illinois State Geological Survey expended all but $8,200 (.14%) of General Revenue monies and $130,900 (52.2%) in the Natural Resources Information Fund. Expenditures in the Natural Resources Information Fund were intentionally light as revenues did not fully support the appropriation.

Allocated Funds Of the allocated FY90 funds totalling $775,200 (Tables F-3, F-4 and F-5), the Illinois State Geological Survey expended all monies in the Hazardous Waste Research Fund and Repair and Maintenance. Lapses occurred in LUMP $1,400 (0.1%) and Build Illinois Repair and Maintenance $1,000 (.01%). The unexpended Build Illinois Equipment funds totalling $93,100 (22.1%) have been reappropriated and will be fully expended in FY91.

Table F1 FY90 Financial Statement for the Illinois State Geological Survey General Revenue Fund: July 1, 1989 through September 30, 1990

Line Item	Appropriation for FY90	Transfers	Vouchered to Date	Outstanding Obligations This Date	Balance Available for FY90
Personal Services	$5,034.6	$0.0	$5,034.6	$0.0	$0.0
Retirement Contributions	538.6	0.0	538.6	0.0	0.0
Social Security Contributions	14.4	(1.3)	7.2	0.0	5.9
Contractual Services	102.9	(17.1)	85.7	0.0	0.1
Topomapping	20.3	0.0	20.3	0.0	0.0
Travel	39.2	1.2	40.4	0.0	0.0
Commodities	72.5	12.3	84.7	0.0	0.1
Printing	35.7	(4.2)	30.7	0.0	0.8
Equipment	39.3	0.7	39.9	0.0	0.1
Computer Based Research	47.2	2.5	49.1	0.0	0.6
Telecommunications	54.0	4.6	58.6	0.0	0.0
Operations of Auto Equipment	35.1	1.3	36.2	0.0	0.2
GeoMapping - Other Expenses	26.0	0.0	25.6	0.0	0.4
TOTALS	$6,059.8	$0.0	$6,051.6	$0.0	$8.2

Table F2 FY90 Financial Statement for the Illinois State Geological Survey Natural Resources Information Fund: July 1, 1989 through September 30, 1990

Line Item	Appropriation for FY90	Vouchered to Date	Outstanding Obligations This Date	Balance Available for FY90
Lump Sum - Operating Expenses	$250.0	$120.0	$0.0	$130.0
Refunds	1.0	0.1	0.0	0.9
TOTALS	$251.0	$120.1	$0.0	$130.9

NRIF Revenue July 1, 1989 through June 29, 1990 was $141.8.

Table F3 FY90 Financial Statement for the Illinois State Geological Survey Lands Unsuitable for Mining Program: July 1, 1989 through September 30, 1990

Line Item	Allocation for FY90	Transfers	Available Allocation	Vouchered to Date	Outstanding Obligations This Date	Balance Available for FY90
Personal Services	$113.4	$0.0	$113.4	$113.4	$0.0	$0.0
Retirement Contributions	0.0	0.0	0.0	0.0	0.0	0.0
Social Security Contributions	0.6	0.1	0.7	0.7	0.0	0.0
Group Insurance	8.3	0.0	8.3	6.9	0.0	1.4
Contractual Services	0.8	0.0	0.8	0.8	0.0	0.0
Travel	5.4	0.0	5.4	5.4	0.0	0.0
Commodities	0.0	0.0	0.0	0.0	0.0	0.0
Printing	0.0	0.0	0.0	0.0	0.0	0.0
Equipment	0.0	0.0	0.0	0.0	0.0	0.0
Computer Based Research	4.2	(0.1)	4.1	4.1	0.0	0.0
Telecommunications	2.5	0.0	2.5	2.5	0.0	0.0
Operations of Auto Equipment	0.0	0.0	0.0	0.0	0.0	0.0
TOTALS	$135.2	$0.0	$135.2	$133.8	$0.0	$1.4

Table F4 FY90 Financial Statement for the Illinois State Geological Survey Groundwater Protection Act: July 1, 1989 through September 30, 1990

Line Item	Allocation for FY90	Vouchered to Date	Outstanding Obligations This Date	Balance Available for FY90
Lump Sum - Operating Expenses	$125.0	$125.0	$0.0	$0.0
TOTALS	$125.0	$125.0	$0.0	$0.0

Table F5 FY90 Financial Statement for the Illinois State Geological Survey Miscellaneous Funds: July 1, 1989 through September 30, 1990

Line Item	Allocation for FY90	Vouchered to Date	Outstanding Obligations This Date	Balance Available for FY90
Repair & Maintenance-Building	$5.0	$5.0	$0.0	$0.0
Build Illinois Equipment*	421.8	328.7	92.5	0.6
Repair & Maintenance-Major Equipment	88.2	87.2	0.0	1.0
TOTALS	$515.0	$420.9	$92.5	$1.6

* Remaining funds rollover in FY91.